TIONAL POPLAR RIVER WATER QUALITY STUDY

Appendix C: Biological Resources

1979

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Prepared by the Biological Resources
Committee of the International
Poplar River Water Quality Board,
International Joint Commission

1979

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International Poplar River Water Quality Board
International Joint Commission
Canada and the United States

Gentlemen:

We are pleased to submit the final report of the Biological Resources Committee - Appendix C of the International Poplar River Water Quality Board.

This report consists of the Environmental Impact Assessment, Recommendations and Annexes, prefaced by an Abstract and Summary of Impact Predictions.

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ABSTRACT AND SUMMARY OF IMPACT PREDICTIONS

Our assignment was to describe the potential impacts of the Saskatchewan Power Corporation (SPC) Coronach Project and the proposed apportionment of the water of the Poplar River drainages on the biological resources of the Poplar River Basin in Montana. These resources include aquatic plants, aquatic invertebrates, fish and wildlife. Impact assessments are determined from the proposed apportionment statistics, SPC Coronach Project plans and specifications, scientific literature, other International Poplar River Water Quality Board Committee reports and consultation with other experts. They are followed by suggestions for reduction of predicted negative impacts and monitoring recommendations.

It was found that the proposed apportionment of the waters of the Poplar River Basin, primarily through the regulation of Cookson Reservoir, would lead to substantial changes in the flow characteristics of the East Poplar River and Poplar River:

Percent reduction in bankfull hydraulic characteristics at the International Boundary (from Annex 4):

	Width	Depth	Velocity
East Poplar River	53-68	42-56	15-21
Poplar River	17-40	13-31	4-10

These hydraulic changes will cause habitat changes and result in the following adverse impacts on the biological resources of the Poplar River Basin in Montana:

1. Up to a 50 percent increase in growth of rooted aquatic plants (macrophytes) in the East Poplar River.

2. Up to a 25 percent decrease in growth of current-dependent algae in the East Poplar River.

3. Up to a 75 percent decrease in the walleye population in the lower East Poplar River due to loss of habitat and decrease in channel size.

4. Up to a 50 percent reduction in annual duck production in the East Poplar River due to habitat alteration - primarily encroachment of rooted aquatic plants.

5. The above impacts have already commenced on the East Poplar River with the closing of the Morrison Dam; the Committee felt that these will approach the levels predicted within the life of the SPC Coronach Project.

The Committee identified the following impacts but were unable to fully quantify them:

1. Increased numbers of rooted aquatic plant-dependent aquatic invertebrates in the East Poplar River and Poplar River above the confluence with the West Poplar River due to increased growth of macrophytes.

2. Replacement of aquatic invertebrates dependent upon moving water in the East Poplar River and Poplar River above the confluence with the West Poplar River with those which prefer slower moving or standing water.

3. The long term reductions in stream bottom will cause proportional reductions in invertebrate numbers and biomass.

4. Reduction in numbers of northern pike in the East Poplar and pike and walleye in the Poplar River above the confluence with the West Poplar due to the reduction in stream flows.

5. Changes in species composition and population size of fish other than walleye and northern pike; these were unquantified due to a lack of background information on these species.

6. Reduction in annual duck production in the Poplar River above the confluence with the West Poplar due to habitat alteration - primarily encroachment of rooted aquatic plants.

7. Reduction in the diversity and abundance of shorebirds in the lower East Poplar due to the downstream progression of the morphological, floral and faunal characteristics of the upper East Poplar.

8. Due to possible warm water discharges in the summer, there may be fish kills below Cookson Dam.

Sufficient information was not available to determine impacts to the biological resources other than those mentioned above; although the magnitude of habitat alteration caused by the SPC Coronach Project will result in changes in diversity, abundance and distribution.

We found there would be no significant adverse impacts:

1. On the biological resources in the Poplar River below the confluence of the West Poplar River.

2. On the biological resources of the Poplar River Basin due to changes in water quality resulting from the SPC Coronach Project.

Recommendations for amelioration of some of the above predicted adverse impacts and further study to satisfy assessment deficiencies are presented in the last section of this report. In summary:

1. We concluded that a minimum allocation of 92 percent of the mean annual flow of the East Poplar River would be required to the U.S. in order to restore and maintain fish and wildlife habitat at preproject levels.

2. If Poplar River Task Force's apportionment of the East Poplar does occur then we recommend that there be no further use of Poplar River water in Canada. Consideration could be given to use of this stream for mitigation of adverse impacts on the East Poplar River.

3. We identified other habitat enhancement measures in northeastern Montana and southern Saskatchewan which, while not replacing the losses in fish or wildlife production in the East Poplar River, would adequately compensate for these losses in the northeastern area of Montana.

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INTRODUCTION

I. PUBLIC HEARINGS

The International Joint Commission (IJC) held public hearings in Scobey and Regina in November 1977 to assess the degree of public concern about the Saskatchewan Power Corporation (SPC) Coronach power development on the Poplar River (hereafter referred to as SPC Coronach Project). Briefs were presented by public officials, various groups and citizens at large. Some briefs presented in Scobey expressed concern about the biological impacts of the SPC Coronach Project.

II. COMMITTEE ASSIGNMENT AND TASKS

The Biological Resources Committee (BRC) was one of five committees assigned to provide information and recommendations to the International Poplar River Water Quality Board (IPRWQB) and thence to the IJC to answer questions raised by the governments of Canada and the U.S. These related to the transboundary effects of the SPC Coronach Project and ancillary facilities, and to water quality changes resulting if apportionment of the Poplar River is made as recommended by the International Souris-Red Rivers Engineering Board's Poplar River Task Force. The study assignment given to this Committee, outlined in the Board's plan of study, is excerpted as follows:

> "The Biological Resources Committee will provide information to the Board, and other committees as appropriate, on the extent and viability of the biological resources presently associated with the Poplar River system. The committee shall also predict the impact on these resources in the U.S. portion of the Poplar River caused by changes in water quality due to the development of the Saskatchewan Poplar River Power Plant and ancillary facilities, but as constrained by the recommended flow apportionment. The committee shall address item 3(3) of the Directive of the International Joint Commission in that they shall examine and report upon the 'nature, location and significance of fisheries and wildlife dependent on the waters of the Poplar River'."

Tasks that resulted from this assignment included:

- obtain and review all available data for adequacy;
- identify those biological resources that are presently dependent or partially dependent on the waters of the Poplar River;

- identify data deficiencies and define additional studies and/or data needs;

- determine the biological system's dependence on and sensitivity to water quality factors as well as stream morphological and hydrological factors;

- review biological water quality criteria and objectives as developed by the Water Use and Quality Objectives Committee and recommend changes as appropriate;

- based upon identified biological resources identify those organisms that could or have potential to be used as indicators of water quality change;

- using the predicted changes in water quality and quantity, as provided by the Surface Water Quality Committee, determine the impacts to the biological community after construction and operation of the power plant and ancillary facilities;

- make recommendations on measures to reduce and/or affect identified resource losses.

III. STUDY APPROACH

We considered "biological resources" to include the following resource groups - aquatic and riparian vegetation, aquatic invertebrates, fish and wildlife. For each of these groups we obtained and reviewed available data on species occurrence, distribution, abundance and tolerance to environmental stress. Using these data plus predictions made by the Surface Water Quality Committee and our own advisors, we assessed the impact of the SPC Coronach Project on the biological resources of the Poplar River. In performing this assessment we singled out "indicator species" for each resource group and used these primarily in defining impacts on that resource group.

Our work commenced in January of 1978; a final draft was submitted to the board in January 1979. During this period the Committee met ten times, including a field trip to the study area.

IV. REPORT ORGANIZATION

This report consists of the following major sections: Introduction, Effect of Project, Mitigation Plan and Recommendations. The Effect of Project section is subdivided by resource groups: aquatic

and riparian vegetation, aquatic invertebrates, fish and wildlife. Each of these sections has its own introduction, methods, results, discussion, summary and references. A resumé of each of these sections is included in the Abstract and Summary of Impact Predictions section, following the letter of transmittal. In addition to the actual impact assessment, various alternatives and recommendations for further study are included in this report. Annexes to various sections are also included.

DESCRIPTION OF STUDY AREA

The Poplar River is comprised of three forks, referred to hereafter as East Poplar, Poplar, and West Poplar in the Wood Mountain region of Saskatchewan. Each fork separately crosses the United States-Canadian border to join at two locations within Montana (Figure 1). The SPC Coronach Project is located on the East Poplar River; this stream and the Poplar River join near Scobey, Montana about 19 km (12 mi) below the International Boundary. The West Poplar joins the Poplar mainstem about 40 km (25 mi) further downstream. A major portion of the West Poplar drainage is found in Montana with a drainage area of 375 km^2 (145 mi^2) at the border versus a total area of 2615 km^2 (1010 mi^2) at its mouth. In contrast, the Poplar and East Poplar have a major portion of their drainages in Canada with areas of 927 and 1403 km^2 (358 and 542 mi^2) upstream from International Boundary, respectively, versus total areas of 1507 and 1940 km^2 (582 and 749 mi^2) at points near Scobey (Poplar River Task Force 1976). The total drainage area of the Poplar Basin equals about 8624 km^2 (3330 mi^2).

The three forks of the Poplar mainstem and their points of confluence divide the Poplar River system into five segments - three upper reaches consisting of the three forks, a middle reach of the mainstem between the confluences of the forks (a 40 km (24 mi) segment), and a lower reach of the mainstem below the confluence of the West Fork to its mouth near Poplar (a 64 km (40 mi) segment). For biological reasons we have further subdivided the East Poplar into the upper and lower reaches; the former being the first 15 km (9.3 mi) below the International Boundary and the latter being the lower 19 km (12 mi). In addition to the three major forks, other tributaries of some import to the Poplar region include Girard and Coal Creeks located near the International Boundary, and Butte Creek located entirely within Montana. These smaller streams are not given extensive consideration in this review.

The Poplar River Basin is characterized by a continental climate with cold and dry winters, moderately warm and wet springs, and warm and dry summers. The soils of the region consist of alterations in alluvium, till and other geological materials that have been affected by varying conditions of climate, topography, and living organisms.

The Poplar River is a low-gradient, sinuous prairie stream with its natural flow pattern characterized by high spring flows and low summer flows. Physically it is made up of large pools and shallow riffles. Gravel is the dominant streambed material in the riffles, whereas sand, silt and mud bottoms predominate in the pools. At least 28 species of fish occur in the Poplar River downstream from the International Boundary. Dominant sport fish include walleye (*Stizostedion vitreum*) and northern pike (*Esox lucius*). This resource is utilized as a sport fishery.

At least 45 species of waterfowl utilize the Poplar River drainage at various times during the year. Most of these pass through

during migration. Fourteen waterfowl species are known to breed here. In addition the drainages provide either seasonal or year-long habitat for at least 4 species of reptiles and amphibians, 23 species of mammals and over 100 other avian species. While there is some sport hunting for ducks, geese, pheasant, grouse, antelope and deer, ammenities are a major consideration in Montanans' minds when discussing potential impacts of the SPC Coronach Project on the wildlife resource.

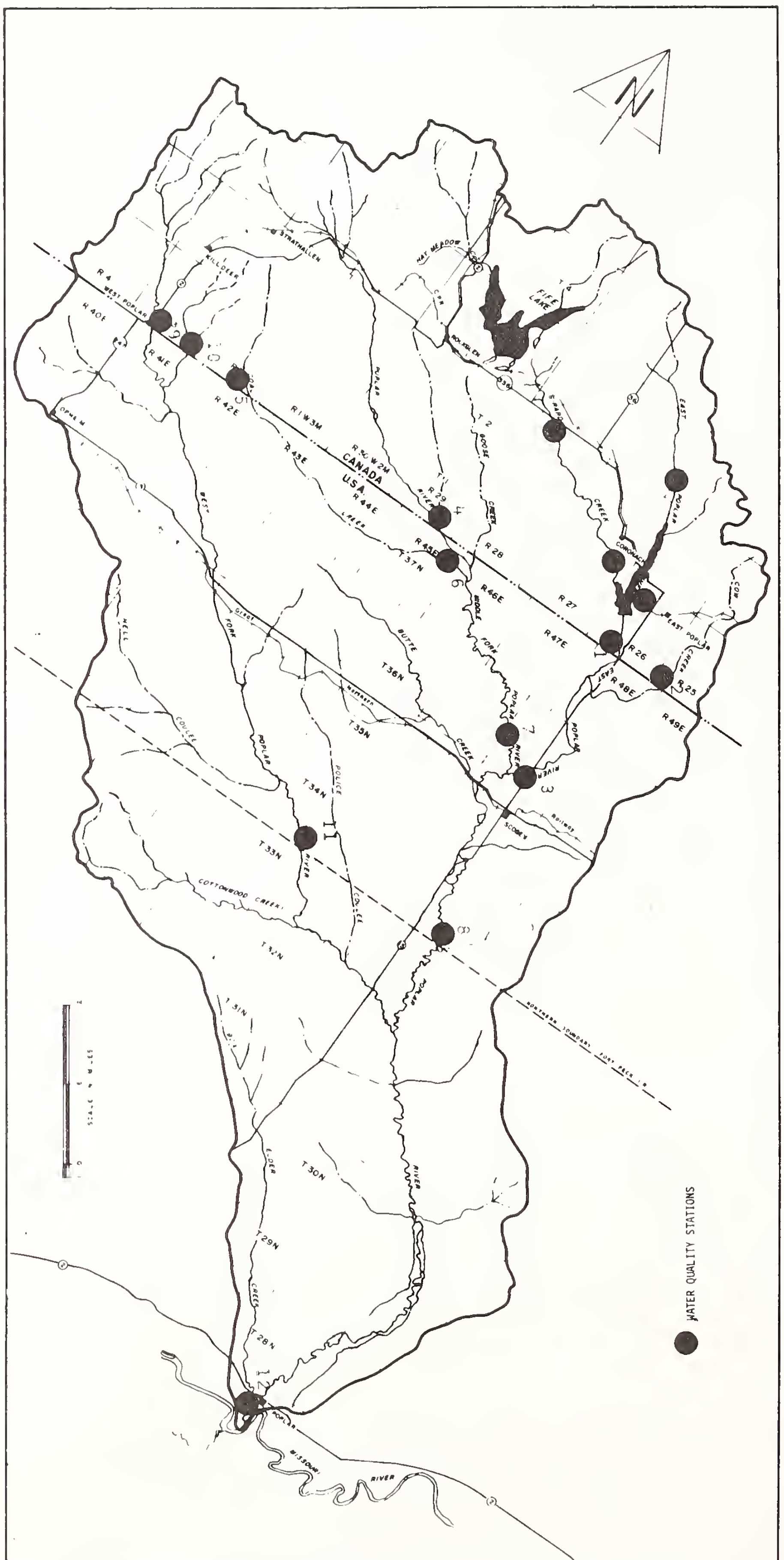

Figure 1. Poplar River Basin

DESCRIPTION OF PROJECT

The Saskatchewan Power Corporation is in the process of constructing a 300-megawatt, electrical generating station near Coronach scheduled to go on line prior to 1980. Their proposal indicates that this facility will expand to two, and possibly four units, sometime after this date. The plant is located about 37 km (23 mi) north of Scobey, Montana, and about 13 km (8 mi) north of the Canada border. Coal mined in the Coronach vicinity will be burned in the power plant; the water required for the flow-through cooling systems will be obtained from Cookson reservoir, an impoundment of the East Poplar River near the generator site. Construction of the dam for this impoundment has been completed , and the reservoir is now filled.

Significant evaporative losses, both natural and induced, are projected. As a result, significant increases in dissolved solids and other constituent concentrations are expected to occur in the reservoir and therefore in the East Poplar River. Such increases would affect downstream water quality sites in Montana. Other major impacts could include: 1) introduction of toxic and harmful substances into the stream via fly-ash and bottom-ash slurries and from anti-corrosive additive substances, 2) disruption of important aquifers during the mining phase, and 3) wind-borne stack effluents. These could prove to be deleterious to downstream biota and wildlife.

In addition to direct effects of the power plant, apportionment by the IJC of flows in the West Poplar, Poplar and East Poplar to Canada and the U.S. plus regulation of reservoir discharges by the SPC could have significant effects on the flows in the Montana portions of these streams resulting in changes in stream morphology and bedload transport. These potential disruptions could destroy the habitat of certain aquatic biota and wildlife living in or along these streams.

PROJECT EFFECTS ON BIOLOGICAL RESOURCES

I. AQUATIC PLANTS

A. Introduction

Plants are important because they serve as food and cover for aquatic invertebrates, fish, waterfowl, shorebirds, and other wildlife. They also remove nutrients from the water and add dissolved oxygen during daylight hours. On the other hand, plants may cause taste, odour and toxicity problems, interfere with recreation, fish spawning and waterfowl movement, deplete dissolved oxygen at night and facilitate the accumulation of sediment on the river bottom.

B. Baseline Information on Resource

1. Methods: Information on general habitat and distribution of algae in the Poplar River system was compiled from available literature (Cullimore 1976; Bahls 1977; Saskmont 1978). Canadian studies (Cullimore 1976; Saskmont 1978) have focussed primarily on phytoplankton (free-floating algae) with a limited amount of work on the periphyton (attached algae). All Canadian work has been confined to the East Poplar River Basin. The emphasis of the one U.S. study (Bahls 1977) was on benthic diatom associations, including those of the East Poplar River, the Poplar River and the West Poplar River. Quantitative aspects of periphyton abundance and diversity on the U.S. side of the border were extracted from Bahls (1977). One additional composite periphyton sample was collected by Bahls from natural substrates on May 24, 1978, from the East Poplar River at the International Border. This sample was collected and analyzed in a fashion identical to the techniques used by Bahls in 1977. Rates of periphyton chlorophyll *a* accrual on glass slides were obtained for eight stations on the U.S. side of the border from the files of the Water Quality Bureau, Montana Department of Health and Environmental Sciences, Billings.

A list of aquatic and "riparian" macrophytes of the East Poplar Basin in Saskatchewan was compiled from available literature (Baron 1974; Cullimore 1976; Saskmont 1978). A reconnaissance survey of aquatic macrophytes in the first 5 km (3 mi) of the East Poplar River below the International Border was conducted on May 24, 1978 by our Committee. No quantitative measurements of macrophyte communities have been made in either the Canadian or the U.S. portions of the Poplar River Basin.

Specific habitat requirements of aquatic plants in the Poplar River Basin have been characterized only in terms of the historical water quality measurements compiled by the Surface Water Quality Committee; specific physical requirements (depth, current velocity, substrate, etc.)

of plants as they occur in the Poplar River have not been measured. Similarly, the use of specific aquatic plants in the river by other biological resource groups has not been observed and recorded.

2. Results and Discussion

Algae: The algal flora of the Poplar River system in Saskatchewan and Montana consists of at least 122 genera, 272 species, and 309 varieties (Annex 1). These taxa are distributed among five major groups:

Division	Genera	Species	Varieties
Chlorophyta (green algae)	50	61	63
Euglenophyta (euglenoid algae)	4	4	4
Chrysophyta (golden-brown algae)	46	180	215
Pyrrophyta (dinoflagellates)	1	1	1
Cyanophyta (blue-green algae)	21	26	26
Total Taxa	122	272	309

From the standpoint of diversity, the only significant groups in the Basin are the golden-browns (mostly diatoms), the greens, and the blue-greens, in descending order of importance. The great majority of the algae, except those from Fife Lake, Coronach Reservoir, and Cookson Reservoir, are periphytic types, although many of these were collected using techniques employed for sampling phytoplankton and reported as "plankton" (Annex 1). Because of the prior emphasis for study in the East Poplar River Basin, most of the reported algae are from the East Poplar River. Again, the East Poplar River is dominated by diatoms, green and blue-green algae:

Division	Genera	Species	Varieties
Chlorophyta (green algae)	48	59	61
Euglenophyta (euglenoid algae)	4	4	4
Chrysophyta (golden-brown algae)	45	136	159
Pyrrophyta (dinoflagellates)	1	1	1
Cyanophyta (blue-green algae)	19	24	24
Total Taxa	117	224	249

Two species of potentially toxic and bloom-forming blue-green algae were reported from Cookson Reservoir in 1977: *Anabaena flos-aquae* and *Aphanizomenon flos-aquae* (Saskmont 1978). These species had not reached bloom proportions at the time of sampling. These samples were

collected in April and early June, which is before the usual time for the onset of blue-green algal blooms in lakes at this latitude.

Cladophora was reported to be the most abundant non-diatom alga in the Poplar River system south of the International Border (Bahls 1977). *Cladophora* is a large, perennial, filamentous green alga favored by a firm substrate and water that is hard, rapidly flowing, and rich in nutrients (Whitton 1970). In May 1978, members of the Committee observed long streamers of *Cladophora* in both the Poplar River and East Poplar River, but only below culverts or in shallow, rocky riffles.

According to Bahls (1977), the East Poplar River has more genera of non-diatom algae than the West Poplar or the upper Poplar in Montana. He reported 26 genera from the East Poplar River, 21 genera from the upper Poplar River (above its confluence with the East Poplar), and 20 genera from the West Poplar River.

The diatom flora of the Poplar River system in Montana is dominated by the genus *Nitzschia* , both in number of varieties (44) and in percent relative abundance (39.4%) (Bahls 1977). *Nitzschia* is a reliable indicator of total nitrogen in water; its relative abundance is usually proportional to total nitrogen content (Cholnoky 1968). The relative abundance of *Nitzschia* species in the East Poplar River was the lowest of the three main branches of the Poplar River (32.2%), but still high in comparison to other Montana rivers (Bahls 1977).

Achnanthes minutissima is a cosmopolitan diatom in alkaline waters, but it is abundant only where dissolved oxygen consistently approaches or exceeds saturation (Cholnoky 1968). This diatom was uncommon in all segments of the Poplar River system in Montana (Bahls 1977), suggesting periodic dissolved oxygen stress in these waters.

The diatom flora of the Poplar River system in Montana as presented by Bahls (1977) is largely freshwater (Lowe 1974). However, based on their distribution among the river's three major forks, there are much greater numbers of salt-loving diatoms in the East Poplar and upper Poplar than in the West Poplar River. Thus, the West Poplar appears to carry a significantly lower salt (i.e. total dissolved solids) load than the other two forks. This conclusion is supported by chemical data.

Bahls (1977) reported the East Poplar River to have more kinds of diatoms, more "exclusive" kinds of diatoms, and higher diatom diversity than any other comparable segment of the river system in Montana. Floristically, the East and West Poplar rivers are very dissimilar. Yet, neither fork exerts a significant influence on the flora of the lower Poplar River below their confluences. Mean diatom diversities for all segments of the river in Montana are indicative of unpolluted waters (Bahls in prep.).

The diatom sample collected from the East Poplar at the International Border on May 24, 1978 (Annex 2) had relatively greater numbers of *Nitzschia* species (56.1%) than previous samples from this

location analyzed by Bahls (1977) in 1975 and 1976. *Achnanthes minutissima* was present only in trace amounts which was less than all prior values. This may indicate nitrogen enrichment and depressed oxygen levels over the intervening years. However, diversity was still high.

Insufficient information is available on the distribution and abundance of algae to ascertain the presence of rare and endangered species in the Poplar River Basin.

Rates of chlorophyll *a* accrual in the Poplar River (Table 1) are, on the average, lower than those for most other rivers in Montana for which comparable data are available (Klarich 1976; Bahls et al. in prep.). They are, however, of the same order of magnitude as chlorophyll *a* accrual values for the Madison River, Montana which perhaps not coincidentally also has a sizeable macrophyte community in its upper reaches. It is suggested that competition with or inhibition by aquatic macrophytes or other algae may account for the relatively low observed periphyton production in spite of ample nutrient (N and P) concentrations. Other chemical and physical parameters also may be factors in limiting instream periphyton production.

Macrophytes: 81 species of aquatic and riparian macrophytes have been reported from the East Poplar River Basin in Saskatchewan (Annex 3). Not all of these are from the East Poplar River itself, as collecting was also conducted in other aquatic habitats elsewhere in the basin.

Only 22 of the 81 species, in 13 of 32 families, are considered aquatic (Hudson personal communication). Although well over half (73%) of the taxa in Annex 3 are considered "riparian or moist soil" types, there is no clearly delimited riparian community along the East Poplar River in Saskatchewan or Montana.

On May 24, 1978, Committee members walked five km (3 mi) of the East Poplar River immediately below the International Boundary. This reach was clearly dominated by macrophytes rather than by periphyton. The macrophyte community in turn appeared to be dominated by *Myriophyllum exalbescens* and a narrow-leaved species of *Potamogeton*. Other species included:

Carex sp.
Eleocharis sp.
Hippuris vulgaris
Polygonum sp.
Potentilla sp.
Scirpus sp.
Typha sp.

Other sites visited by the Committee in May, including sections of the lower East Poplar, the Poplar and the West Poplar, did not have significant aquatic macrophyte communities. This confirms independent observations (Stewart personal communication) that, except for the upper East Poplar, macrophytes are not a significant constituent of the aquatic flora in the Montana portion of the Poplar River system.

Insufficient information is available on the distribution and abundance of macrophytes to ascertain the presence of rare and endangered species in the Poplar River Basin.

Table 1. Rates of chlorophyll *a* accrual at eight stations on the Poplar River system in Montana, late summer to early fall, 1975 (Files of the Water Quality Bureau, Montana Department of Health and Environmental Sciences, Billings).

Location	Accrual Rate[1]	
	Replicate 1	Replicate 2
East Poplar River near Scobey	0.0187	0.0091
Poplar River above East Poplar River		
Upstream Site "A"	0.0267	0.0204
Downstream Site "B"	0.0223	0.0102
Poplar River below Scobey	0.0533	0.0713
Poplar River above West Poplar River	0.0041	0.0039
West Poplar River near mouth	0.0633	0.0484
Poplar River below West Poplar River	0.0051	0.0063
Poplar River near Poplar	0.0192	0.0140

[1]micrograms/cm^2/day

C. Assessment of Potential Impact on Resource

The following assessment is for two scenarios: I - two plants plus the reservoir on the East Poplar River and II - two plants plus the reservoir on the East Poplar and apportionment as recommended (Poplar River Task Force 1976) on the Poplar and West Poplar. Flow, temperature, TDS, dissolved oxygen, turbidity, and algal nutrients are addressed singly and cumulatively as the parameters most likely to influence aquatic plants. Other parameters are not expected to have a significant effect. Nuisance and toxic algal species are also considered.

1. Flow: (Scenario I) Flow differentials will be most marked in March when the mean monthly flow will be reduced by 87 percent on the East Poplar River at the border. Late spring and autumn flows will be reduced by 20 to 40 percent. Summer flows (July and August) will increase 25 and 46 percent, respectively, while winter (base) flows will increase by as much as 140 percent (Surface Water Quality Committee 1979). As a result of the flow reductions, the East Poplar will become 53 to 68 percent narrower, 42 to 56 percent shallower, and 15 to 21 percent slower at the bankfull discharge stage (Andrews 1979).

Cladophora, the principal algal genus of the Poplar River system, has a bimodal growth pattern at temperate latitudes, with peaks in spring and fall (Whitton 1970). These are the seasons of flow reduction from the East Poplar downstream. The species of *Cladophora* in the Poplar River have been observed to be dependent upon a moderate amount of current velocity for optimal growth. *Cladophora*, along with other current-dependent taxa, will decrease in abundance umder Scenario I. This reduction will likely occur in two stages: 1) an initial reduction in peak seasonal growth due to flow regulation, and 2) a more gradual reduction in annual growth paralleling changes in stream morphology.

Changes in flow and stream morphology will result in entrenchment and downstream expansion of the aquatic macrophyte dominated plant community of the upper East Poplar River in Montana. Downstream expansion may reach to the mouth of the West Poplar River. Although encroachment of macrophytes into open water is already occurring in the East Poplar (R. DeSimone personal communication), the development of macrophyte-dominated plant communities downstream will be gradual, again paralleling changes in stream morphology. Long-term fluctuations in groundwater levels predicted by the Ground Water Quantity and Quality Committee (1979) will not be sufficient to significantly affect riparian vegetation along the East Poplar River near the International Boundary.

(Scenario II) Seasonal flow reductions on the Poplar River above the East Poplar, resulting from a 50 percent apportionment to Canada, will be similar to but less pronounced than reductions on the East Poplar River caused by the Cookson Reservoir. Bankfull discharge will probably become 4 to 10 percent slower, 13 to 31 percent shallower, and 17 to 40 percent narrower (Andrews 1979). These changes will have the same biological effects in the Poplar River as in the East Poplar River,

only they will be less dramatic. Macrophyte and periphyton abundance in the East Poplar will remain unchanged from Scenario I, but the downstream effects will extend beyond the mouth of the West Poplar to its confluence with the Missouri River.

2. Temperature: (Scenario I) Peak temperatures in the East Poplar are not expected to be significantly different than they are now (Surface Water Quality Committee 1979). However, with lower spring flows, temperatures are expected to peak earlier than they would naturally. Most species of *Cladophora* require cool water for optimum growth, hence the spring growth season will be shortened by more rapid warming of the water. This warming will also likely extend the growth season for most macrophytes in the river.

(Scenario II) A 50 percent apportionment of the Poplar to Canada will also result in temperatures that favor macrophyte expansion in this river above its confluence with the East Poplar. Similarly, the growth of current-loving periphyton will be reduced, but probably not to the same extent as in the East Poplar. The combined but reduced spring flows of these two rivers below their confluence will be more quickly warmed, but the effect will be dampened considerably below the mouth of the West Poplar.

3. Total Dissolved Solids (TDS): (Scenario I) TDS in the East Poplar River at the border will increase roughly 50 percent under Scenario I (Surface Water Quality Committee 1979). This means that during the growing season for aquatic plants, TDS will increase from approximately 750 mg/l to approximately 1100 mg/l. Such an increase would bring the TDS from the center of the range for "slightly brackish" water to the upper end of the same range. Increases downstream will be dampened considerably, although absolute values may be higher, but still within the range for "slightly brackish" water (Stewart and Kantrud 1972).

Predicted increases in salinity are not likely to have a significant effect on periphyton species composition in the East Poplar River and waters downstream. Most of the prominent diatoms in the Poplar and East Poplar rivers are indifferent to or stimulated by small amounts of salt, and some, such as *Nitzchia frustulum*, occur over broad ranges of salt concentration (Lowe 1974). However, there will be changes in relative abundance within the existing algal community.

Similarly, predicted increases in salinity are not likely to have a significant impact upon the macrophyte community of the upper East Poplar River. Most of the aquatic macrophytes observed from the river appear to be equally at home in "slightly brackish" and "moderately brackish" water. Furthermore, expected salinities will reach only the upper end of the "slightly brackish" range as characterized by Stewart and Kantrud (1972). Nevertheless, it should be emphasized that sufficient information on the macrophytes is not available for a rigorous assessment of water quality impacts.

(Scenario II) Fifty percent apportionment on the Poplar River will not have a significant effect on TDS in that river above or below its confluence with the East Poplar (Surface Water Quality Committee 1979).

4. Dissolved Oxygen (D.O.): (Scenarios I and II) The composition of the diatom flora of the Poplar River system suggests that dissolved oxygen is periodically depressed to levels well below saturation. This is verified by July and August 1978 early morning D.O. measurements made by the Montana Department of Fish and Game (P. Stewart personal communication). It is not expected that facilities or activities associated with the SPC Coronach Project will have a significant direct effect on dissolved oxygen in the Poplar River system. However, the anticipated increase in rooted aquatic plants may exacerbate already critical early morning D.O. levels, both in summer and winter. This will lead to further reductions in current-loving, oxygen sensitive species, e.g. the diatom *Achnanthes minutissima*.

5. Algal Nutrients: (Scenarios I and II) Nitrogen and phosphorus concentrations are generally more than adequate for maintaining growth of aquatic plants throughout the Poplar River system. There is not expected to be an influx of nutrients as a result of the SPC Coronach Project. In fact, nutrient concentrations will probably decrease as a consequence of reservoir operation (Saskmont 1978; Surface Water Quality Committee 1979). Thus, nutrients are not anticipated to be significant factors in regulating the composition and productivity of the periphyton community in the fully apportioned Poplar River system. Nitrogen indicators, such as the dominant diatom genus, *Nitzschia*, likely will continue as a major component of the river flora.

6. Turbidity: (Scenarios I and II) With the trapping of suspended sediment in Cookson Reservoir there has been a substantial reduction in turbidity of the East Poplar River; turbidity at the border probably will never exceed 10 JTU except during extreme flooding (Surface Water Quality Committee 1979). Apportionment of the Poplar River by means of a reservoir would have the same effect, although it would gradually diminish downstream with the entrance of unregulated tributaries. Whereever water clarity is increased, the growth of aquatic plants will be improved because of the greater penetration of sunlight.

Changes in metal concentrations are not expected to be significant (Surface Water Quality Committee 1979) or to have a significant effect on aquatic plants.

7. Nuisance and Toxic Algal Species: (Scenarios I and II) Diatoms ordinarily dominate the periphyton communities of streams. When a stream is polluted and becomes stressed, green and blue-green algae often replace diatoms as the dominant group because these algae are usually more tolerant of pollution (Patrick 1978). Green and blue-green algae frequently grow to nuisance proportions because they are not effectively grazed by invertebrates. *Cladophora* is one green alga that has become a nuisance in streams elsewhere in Montana. However, it is

anticipated that *Cladophora* will eventually decline in importance as a result of flow reduction and changes in stream morphology (Andrews 1979).

Toxic and bloom-formimg blue-green algae do not flourish in streams, even sluggish streams. They are always planktonic organisns and require standing water for optimum development. Thus, the chances for development of a bloom of toxic algae in the Poplar River or any of its tributaries is practically nil. Chances are greater in Cookson Reservoir, where environmental factors are more conducive to bloom formation and where potentially toxic species (*Anabaena flos-aquae* and *Aphanizomenon flos-aquae*) already have been recorded. If such a bloom were to occur, it would occur in late summer (July through September). Summer demand releases should be free from toxic algal metabolities because the low level (riparian) outlet will be well below the euphotic zone at the average reservoir level. Nothing is known of the bloom potential on the Poplar River in the event of installation of a reservoir.

D. Summary of Impact Predictions (Table 2)

Individually, the only factors that will significantly affect plant populations in the Poplar river system will be flow and turbidity reductions. Flow reduction and early warming will operate together to entrench and expand the aquatic macrophyte community of the Poplar River system. Expansion of aquatic macrophytes will be most dramatic in the East Poplar River approaching an additional 50 percent coverage within the life of the project. Flow reduction and early warming will also reduce populations of current-loving periphyton, again most effectively in the East Poplar. Reduced turbidity will enhance the growth of all aquatic plants below dams. Enhanced macrophyte growth may exacerbate already critical D.O. problems. Changes in flow, temperature, TDS, dissolved oxygen and nutrients will cause minor shifts in the relative abundance of algal and macrophyte species, but there should be no reductions in diversity. Nuisance and toxic growths will not develop in the river but they may be a problem in Cookson Reservoir. There is insufficient information on aquatic macrophytes in the Montana section of the East Poplar River for a rigorous assessment of water quality and water quantity impacts.

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Table 2. Summary of Impact Assessment for Aquatic Plants.

Resource Group	Scenario[1]	Stream morphology	Stream flow	Turbidity (reduction)	TDS	Temperature	Dissolved oxygen	Nutrients	Conservative parameters	pH	Metals	Food	Net Impact	East Poplar (E.P.)	Poplar above E.P.	Poplar between E.P. & W.P.	West Poplar (W. P.)	Poplar below W.P.	Immediately	Within 5 years	Within life of project	As Stream[2] M + QΔ
		Specific Disturbances												Percent and Location of Impact					Time to Anticipated Impact			
Macrophytes	I	+	+	+	0	+	0	0	0	0	0	NA	Expansion	+ 50%	0	+ 15%	0	0	+	+	+	+
Current-loving periphyton	I	-	-	+	0	-	-	0	0	0	0	NA	Reduction	- 25%	0	- 10%	0	0	-	-	-	-
Other algae	I	-	+	+	0	0	0	0	0	0	0	NA	Expansion	+ 25%	0	+ 10%	0	0	+	+	+	+
Macrophytes	II	+	+	+	0	+	0	0	0	0	0	NA	Expansion	+ 50%	+ 25%	+ 20%	0	+ 15%	+	+	+	+
Current-loving periphyton	II	-	-	+	0	-	-	0	0	0	0	NA	Reduction	- 25%	- 15%	- 15%	0	- 10%	-	-	-	-
Other algae	II	-	+	+	0	0	0	0	0	0	0	NA	Expansion	+ 25%	+ 15%	+ 15%	0	+ 10%	+	+	+	+

[1] I - Two power plants plus reservoir on E. Poplar.
II - Two power plants plus reservoir on E. Poplar plus 50% apportionment on Poplar.

[2] As stream morphology and flow changes:
+ significant increase   0 no significant change
- significant decrease   NA not applicable

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II. AQUATIC INVERTEBRATES

A. Introduction

Although aquatic invertebrates are of no direct economic significance to the region, they are important as a food for fish and wildlife. Anticipated changes in the flow regimens, water quality and stream morphology as a result of the proposed power development will have a direct effect on their species numbers and diversities.

For this section we catalogued the existing species diversity and abundance of invertebrates in the East and Poplar rivers on the basis of available information; we identified the habitat requirements and stress factors of some sensitive indicator species, and provided an assessment of the impact of the proposed development on these species.

B. Baseline Information on Resource

1. Methods: Studies by Cullimore (1976), Saskmont (1978), USEPA (unpublished data), and the Saskatchewan Research Council (1978) form the biological data base for this investigation. Field sampling for these studies was carried out intermittently between 1974 and the spring of 1978. Sampling of invertebrates north of the International Boundary was undertaken in the East Poplar River, Girard Creek as its tributary , Fife Lake, Coronach Reservoir, and Cookson Reservoir to meet the needs for environmental impact assessments for two stages of the thermal electric development. Downstream of the International Boundary, samples were collected from each of the three forks of the Poplar River and the Poplar River below its confluence with the East Poplar to its confluence with the Missouri River.

Several methods were employed in the collection of aquatic invertebrates. Zooplankton was examined by Cullimore (1976), Saskmont (1978) and the Saskatchewan Research Council (1978). Cullimore filtered known volumes (1 liter) of water and counted and identified the invertebrates retained on the filter paper. Samples collected by Saskmont were collected with a 12 litre Schindler-Patalas Plankton Trap. The concentrated sample was counted and identified by the Saskatchewan Research Council with the aid of a Sedgewick-Rafter cell. No sampling has been carried out for zooplankton in these streams south of the International Boundary.

Benthic invertebrates were collected in all studies cited. Cullimore (1976) obtained substrate samples with a 7.5 cm core sampler. Invertebrates were examined to a depth of 12.5 cm. The use of this method necessitates a relatively soft substrate with very little or no rock. Saskmont samples were taken with a 232 cm^2 Ekman dredge. US Environmental Protection Agency sampled riffle areas in the river with a Surber Square Foot sampler equipped with No. 60 mesh netting. The

Saskatchewan Research Council complemented Surber samples taken from riffle areas in Canada with qualitative samples taken by sweepnet in the more heavily vegetated portions of the streams.

The seasonal period of sampling varied between studies. The zooplankton was sampled from June through November in 1974 by Cullimore and in April and May by Saskmont. Benthic invertebrates were sampled in the late summer and autumn of 1975 by the Montana Water Quality Bureau and Cullimore. Saskmont sampled the Canadian portion of the river system in April and May of 1977 as part of an environmental impact assessment for Phase 2 of the proposed development. In that same year the US Environmental Protection Agency undertook intensive invertebrate sampling on all three forks and the mainstem of the Poplar River south of the International Boundary. Finally, the Saskatchewan Research Council and the US Environmental Protection Agency undertook a brief sampling program in May of 1978 to address past deficiencies in baseline data on mayfly and caddisfly larvae.

2. Results and Discussion:

Inventory: Canadian data are limited to the East Poplar River, Girard Creek, Fife Lake as a headwater to Girard Creek, the Coronach Reservoir and Cookson Reservoir. Similar data are lacking for the Poplar and West Poplar rivers north of the International Boundary. Data are available from all forks of the Poplar River in the United States but are limited in certain respects. The deficiencies will be addressed later.

Zooplankton: Zooplankton have not been studied intensively. The study carried out by Cullimore (1976) identified only the most common genera occurring in the East Poplar River and Girard Creek in Canada (Annex 5, 6). These included *Daphnia*, *Cyclops* and ostracods. Considerable seasonal variation between sampling sites was noted. One evident trend was the predominance of cladocerans from July through September.

A greater diversity of zooplankton was identified in these streams by Saskmont (Annex 7). The most common groups included nine genera of rotifers, four genera of cladocerans, and three genera of copepods.

The dominant zooplankters in Girard Creek were rotifers and copepods. Protozoans were represented by three genera.

Rotifers were less dominant in the East Poplar River than they were in Girard Creek. Rotifer populations decreased from April to June while the number of cladocerans increased. The boundary station on the East Poplar River, showed the lowest population levels in the study area.

Zooplankton data for the upper Poplar and West Poplar rivers in Canada, and for all three tributaries in the United States were unavailable.

Benthic Invertebrates: Results of benthic fauna analysis by Cullimore (1976) are presented in Annex 8. Samples from the East Poplar River in Canada consisted of nematodes, annelids and molluscs. Dipteran larvae were present at both stations on Girard Creek. The oligochaete, *Tubifex* occurred only at the boundary station of the East Poplar in Canada. *Tubifex* and the midge *Tendipes* can both withstand very low dissolved oxygen levels, whereas most gastropods require quite high levels. On this basis, it has been suggested that the invertebrate population is indicative of marginal water quality in the Girard Creek Basin (Cullimore 1976).

Samples taken in these streams by Saskmont in 1977 (Annex 9, 10) contained a considerably greater diversity of organisms than Cullimore's 1975 sample. The difference between the 1975 and 1977 samples may be due to variation in methods, sample sizes, and sampling dates. As a result, these two studies cannot be directly compared. Samples from Girard Creek contained dipterans, oligochaetes, and gastropods. The East Poplar River yielded primarily chironomids in April, and chironomids and/or oligochaetes in June. Oligochaetes were dominant on both dates at stations upstream and downstream from Cookson Reservoir. Few molluscs were present in these samples as compared with 1975 samples.

Results of studies in the U.S. Section of the Poplar River by the USEPA are presented in Annex 11. All three forks have total numbers of benthic invertebrates at least three times greater than that of the mainstem of the river downstream of Poplar. Although total numbers are similar, species composition in the three forks differs considerably. Diptera are dominant in the East and upper Poplar River. Trichoptera dominate in the West Fork. Successively lower numbers of Trichoptera and Ephemeroptera occur in the West, Poplar and East Poplar rivers. The order is reversed for the Diptera. Trichoptera and Ephemeroptera, possessing external gills, are generally indicators of good environmental quality. The greater species diversity and numbers of these insects in the West Poplar and mainstem suggests that these streams are of better water quality than the East Poplar.

Considerable amounts of data exist on aquatic invertebrates in the Poplar River Basin. However, comparisons of data are difficult because of variations in sampling methods, dates and types of habitats sampled. In order to overcome some of these variations, the Saskatchewan Research Council undertook a brief sampling program of riffle and vegetated zones of the East Poplar River north of the International Boundary in May, 1978. The survey was intended to complement the studies done by the U.S. Environmental Protection Agency with respect to numbers and species diversity of mayfly and caddisfly larvae. One genus of mayfly larvae was sampled in Girard Creek and the East Poplar River below the reservoir. A second, *Callibaetis* sp., was taken by sweep net in the upper reaches of the East Poplar (Annex 12). Three genera exclusive of *Callibaetis* were collected in the lower East Poplar by the USEPA. Three genera of stream-dependent caddisfly larvae were collected by Surber sampler. Four others were taken from among emergent macrophytes by sweep net. No differences in species

diversity were apparent at sampling points above and below the Cookson Reservoir.

A brief qualitative sampling program was undertaken on the three forks of the Poplar River on the U.S. side of the International Boundary in the spring of 1978 (Annex 13).

A summary has been prepared of habitat preferences of several genera of Ephemeroptera and Trichoptera larvae (Table 3) based primarily on reference material taken from Hart and Fuller (1974). The table includes several genera not found in the Poplar River but which are known to occur in the Poplar River Basin. Table 4 provides the extremes of several chemical parameters at which various genera of Ephemeroptera and Trichoptera are known to survive. This table identifies only those which are known to tolerate the described conditions not necessarily excluding other genera.

All but three genera of Ephemeroptera found in the Poplar River are stream-dependent, living in slow to moderate currents. Although most of the genera are found on rock and gravel substrates they also appear tolerant of other substrate materials including sand, mud, silt, vegetetion, debris and wood. It is apparent that at least five genera of mayflies present are dependent on flowing water and that this parameter is more critical to their survival than the substrate type. Two genera, *Epheron* and *Caenis*, are known to occur in both static and slow-flowing waters on substrates ranging from rock to mud, silt and vegetation. *Callibaetis* is exclusively a pond-dweller thriving in vegetated ponds and pools.

Caenis and *Callibaetis* were the only genera of mayfly larvae reported from upstream and immediately downstream of the reservoir in May 1978. However, the absence of other species may be related to the ephemeral characteristics of the stream, and the limited sampling program, rather than appropriate substrate.

The genera of caddisflies found in greatest abundance throughout the Poplar River drainage were *Hydropsyche* and *Cheumatopsyche*. Both are net-building genera dependent on a moderate to fast current and a rock or gravel substrate. Other stream-dependent genera found in the Poplar River were *Neureclipsis* and *Psychomia*. Two genera of case-building caddisflies were found in the qualitative shore collections taken in Saskatchewan. Case-building species, except *Helicopsyche*, are generally restricted to vegetated pool areas and littoral zones. Their absence from samples collected in the United States is probably a reflection of sampling technique rather than distribution. These genera are not typically found in substrates normally sampled by a Surber sampler.

Some general tolerances to extremes of several chemical parameters have been described (Table 4) for the genera known to occur in the Poplar River area. Of the parameters listed, dissolved oxygen has been identified as one which might deviate from historic levels.

Table 3. Habitat preferences of several genera of Ephemeroptera and Trichoptera larvae known to occur in the Poplar River system.[1]

Genus	Water			Current			Substrate						
	Lake	Pond	Flowing	Slow	Med.	Fast	Rock	Gravel	Sand	Mud	Silt	Veg.	Debris & Wood
Ephemeroptera													
Ephoron	x		x	x						x			
Stenonema			x	x	x		x			x	x	x	x
Heptagenia			x	x	x		x						
Baetis			x	x	x	x	x	x				x	x
Isonychia			x			x	x	x				x	x
Paraleptophlebia			x	x	x							x	x
Caenis		x		x			x				x	x	x
Tricorythodes				x			x				x	x	x
Callibaetis		x										x	
Trichoptera													
Cheumatopsyche			x			x	x						x
Hydropsyche	x		x			x	x						x
Helicopsyche			x			x	x						
Neureclipsis			x	x	x							x	
Ptilostomis		x										x	x
Limnephilus		x										x	x
Agraylea	x	x	x	x								x	
Polycentropus	x	x	x	x	x	x		x	x	x	x	x	x
Psychomyia			x			x	x	x					

[1]Source: Hart and Fuller (1974).

Table 4. Benthic species present in extremes of several chemical and physical parameters.[1]

	pH		Alk.	Cl	Cl & Mg	Fe	DO	T.H.[2] & Cl	SO_4	BOD	NH_3	Turbidity	Ca
	<4.5	>8.5	>210	>2400	>2000 >150	>5	<4	>300 <1000	>400	>5.9	>5	>72,000	>350
Ephemeroptera													
Isonychia sp.		x								x		x	
Heptagenia sp.										x		x	
Baetis sp.			x	x	x				x	x	x	x	x
Callibaetes sp.			x	x	x		x[3]		x				
Tricorythodes sp.			x					x	x	x		x	x
Caenis sp.			x				x	x	x	x		x	
Paraleptophlebia sp.							x[3]						
Stenonema femoratum							x[3]						
Trichoptera													
Net Builders													
Hydropsychidae							x[3]						
Hydropsyche cuanis		x											
H. bifida gp.		x		x					x		x		x
H. phalerata		x								x			
H. simulans		x											
H. betteni			x							x	x		x
H. frisoni												x	
H. hageni										x			
H. orris			x										
H. recurvata										x			
Neureclipsis prob. *crepuscularis*								x		x	x		x
Cheumatopsyche sp.								x		x	x	x	x
Case Builders													
Helicopsyche prob. *borealis*								x	x				

[1]Source: Hart and Fuller (1974).
[2]T.H. - Total Hardness
[3]Source: Gaufin and Tarzwell (1956).

More specific data on tolerances of mayfly and caddisfly larvae to low dissolved oxygen levels are provided by Surber and Bessey (1974). These data are summarized below showing minimum D.O. levels for the survival of experimental animals for 12 hours:

	Minimum D.O. Level (ppm)
Ephemeroptera	
Isonychia bicolor	3.0
Leptophlebia sp.	1.2
Stenonema tripunctatum	2.0
Stenonema heterotarsale	1.5
Stenonema vicarium	2.0
Stenonema acres	1.0
Stenonema femoratum	2.5
Heptagenia flavescens	2.5
Heptagenia maculipennis	2.0
Ephoron leukon	1.0
Hexagenia limbata	0.5
Trichoptera	
Hydropsyche slossonae	3.5

Surber and Bessey (1974) acknowledge that the experiments might have been very different if different current velocities had been used. Gaufin (1973) conducted experiments on stoneflies, mayflies and caddisflies which indicated complex interrelationships between dissolved oxygen and temperature. He concluded that they do not have an apparent ability to get along without oxygen for an extended period but can survive very low levels for short periods by greatly reducing their activity. Gaufin, therefore, listed for Montana species an average minimum dissolved oxygen requirement of 4.6 mg/l for Ephemeroptera over a 30 day test period and 4.0 mg/l for Trichoptera over an 85 day test period.

Temperature also has a potential for significant change from historical seasonal patterns. A tolerance of the aquatic invertebrates in the Poplar River to a broad range of temperatures is known through their survival over a temperature range from near 0°C in winter to a historical maximum of 29°C. Any changes in the river system which may alter the thermal regime may, however, be reflected in the failure of certain species to survive. Death may either result from exposure of larval stages to temperature extremes or from introduction of adults to environmental conditions intolerable to the species through premature emergence.

C. Assessment of Potential Impact on Resource

East Poplar River

Any changes in the river system which will affect stream shape, temperature, dissolved oxygen or water quality will be reflected in the

quantity and species diversity of the aquatic invertebrates present. The following considerations apply to one dam and one or two generating units on the East Poplar River.

1. Morphometry: Morphometric changes in the stream characteristics of the East Poplar River have been predicted as a result of reduced flows imposed by the Cookson Reservoir (Andrews 1979). The changes will be expressed in reduced channel dimensions, increased siltation of riffle areas and increased macrophyte growth. Decrease in stream channel area will result in a direct reduction in habitat for flowing-water species of invertebrates including most mayflies (Ephemeroptera) and the net-building caddisflies (Trichoptera). These species will be replaced by ones more tolerant of pools, mud substrates and increased aquatic macrophyte growth. The populations of the following genera of mayflies and caddisflies will decline and may eventually disappear from the East Poplar River:

Ephemeroptera	Trichoptera
Baetis sp.	*Hydropsyche* sp.
Pseudocloeon sp.	*Cheumatopsyche* sp.
Stenonema sp.	*Neuroclipsis* sp.
Heptagenia sp.	*Psychomia* sp.
Isonychia sp.	
Paraleptophlebia sp.	
Tricorythodes sp.	

The above mayfly genera will be replaced largely by increased numbers of *Callibaetis* sp. and to a lesser extent *Caenis* sp. and *Ephoron* sp. The net-building genera of caddisflies will be replaced by case-building groups such as *Oecetis* sp., *Limnephilus* sp. and others which thrive on organic substrates among rooted vegetation.

Changes in the described morphometric characteristics will result in the depletion of black flies (Simuliidae) which are dependent on riffle areas, but will favor the proliferation of midges and mosquitoes (Chironomidae and Culicidae). Clams (Pelecypoda) will also decline in numbers. Snails (Gastropoda) will find more favorable habitat in the vegetated pool areas.

On the basis of available data, quantification of anticipated population changes due to changed stream morphometry was not attempted. Initially, replacement of stream-dependent species by those which thrive in pool areas will not result in a significant net change in invertebrate production. However, the change in community types from riffle to pool inhabitants may be reflected in corresponding changes in predator populations.

Long-term changes (30 to 50 years) in stream-pool characteristics through reductions in area (Andrews 1979) will result in proportional reductions in invertebrate numbers and biomass.

2. Temperature: No changes in maximum and minimum temperature are predicted for the East Poplar River as a result of the dam, reservoir and associated two-unit thermal generating stations (Surface Water Quality Committee 1979). Temperature increases which might accelerate emergence of aquatic insects in the months of April to June are unpredictable. Thermal discharges into the reservoir should be cooled by mixing with incoming spring runoff water and the colder reservoir. As a result reservoir discharge temperatures should be comparable to those in the East Poplar River at the border. However, should any extended (two weeks or longer) thermal releases occur at this time of year, they could trigger premature emergence of certain insect species which may be depleted by ambient temperatures unsuitable for reproduction.

3. Dissolved Oxygen: Natural reduction in flow in the East Poplar River have resulted in dissolved oxygen reduction in the pool areas, particularly under winter conditions. However, the aquatic invertebrates present in this river system are generally tolerant of dissolved oxygen levels of less than 4 ppm. Cold winter temperatures increase their tolerance by reducing mobility of the species. Based on predictions of the Surface Water Quality Committee (1979) that dissolved oxygen levels will be maintained within the historic range, depletion of aquatic invertebrates through dissolved oxygen reduction is not anticipated.

4. Water Quality: Projections of changes in water quality in the East Poplar River were provided by the Surface Water Quality Committee (1979). Forced evaporation through thermal discharge into the Cookson Reservoir, combined with addition of salts from the associated ash lagoons are expected to increase the total dissolved solids of the reservoir water to a maximum of 1100 mg/l. No detrimental effects on the invertebrate fauna are anticipated.

Considerations of changes in selected heavy metals, nutrients, and bacteria associated with human wastes have led to the conclusion that no effects are anticipated in the scenarios under consideration.

With the entrapment of suspended sediments in the Cookson Reservoir, turbidity levels of water entering the East Poplar River will be substantially reduced. The effect of these projected changes on the invertebrates of the East Poplar River will be expressed in improved habitat and food resources - increased macrophyte and periphyton growth.

Poplar River

Fifty percent apportionment of the Poplar River at the International Boundary has been proposed. This would have downstream impacts on the invertebrate fauna in the Poplar River similar in nature but smaller in magnitude to those described for the East Poplar River.

The modifying effect of this scenario on the Poplar River downstream from the East Poplar confluence would be proportional to its

contribution of water to that system. This effect, as translated in terms of its implications on the downstream invertebrate fauna, would be negligible.

D. Summary of Impact Predictions

Hydrological changes in the East Poplar River will result in a change in invertebrate fauna from species predominantly stream dependent to those predominantly pool dependent. Unseasonal releases of warm water from the reservoir may result in premature development and emergence of some insect species and lower population levels of these species in some years. No changes in invertebrates are anticipated as a result of predicted changes in dissolved oxygen and chemical water quality. Long term changes in stream : pool characteristics through reduction in area will result in proportional reduction in invertebrate numbers and biomass.

Apportionment of the Poplar River will have an impact similar in nature but smaller in magnitude than predicted for the East Poplar River.

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III. FISH

A. Introduction

The development of the SPC Coronach Project is expected to cause changes in stream characteristics of the East Poplar River below the International Boundary. Some data on the stream morphology, flow regime, temperature and water chemistry of the river, collected prior to plant operation, were available. These data were compared to predicted values resulting from plant operation. Expected impacts on the fish resources of the East Poplar River were then assessed on the basis of predicted changes in stream morphology, flow regime, temperature and water chemistry.

B. Baseline Information on Resource

1. Methods: Inventories of the fisheries resources and habitat were conducted by Montana Department of Fish and Game since 1975 and have continued to the present (Needham 1976; Stewart 1978; Stewart in prep.).

Habitat Description: During the summer of 1977 measurements of channel width and depth were made at low stream flows throughout the drainage. These measurements were made along transects 30.5 m (100 ft) apart in sections 2.4 - 3.2 km (1½ to 2 mi) long. The section locations were chosen to include pool and riffle environments.

Stream temperature was measured using continuously recording thermographs at various locations along all three branches of the Poplar River during the summers of 1975 through 1978. Measurements of dissolved oxygen levels in the East Poplar were taken during the winter of 1977-78 and the summer of 1978. Dissolved oxygen levels were also determined by the USGS as part of a water quality sampling program initiated in 1974 and carried out yearly thereafter.

Distribution and Abundance: The distribution of fish species in the Poplar River was compiled from Brown (1971), Needham (1976), USEPA (1976), Atton (personal communication), Stewart (1978) and Saskmont (1978).

Populations of northern pike and walleye were estimated by the Montana Department of Fish and Game during 1975 and 1977 (Needham 1976; Stewart 1978). Important spawning areas for these fish were identified by capture of ripe fish and collection of eggs and larvae. Estimates of spawning success were based on population size of young-of-the-year fish. Fish movements were assessed by tagging and recapture.

Resource Utilization: Utilization of the fish resource in the Poplar River was measured by mail survey of licensed fishermen and examination of license sales in Daniels County in 1976. (J. Posewitz personal communication).

2. Results and Discussion:

Habitat: Throughout the drainage, riffles make up less than 10% of the stream length. Pools range in length from 91 km (100 yds) to .8 km (0.5 mi) and about 15.2 m (50 ft) to 22.8 m (75 ft) wide; most pools have a maximum depth of 1-1.5 m (3-5 ft). The maximum temperature recorded in the East Poplar was 29°C (85°F) (USGS 1975).

Dissolved oxygen levels measured on the East Poplar in winter dropped to less then 1 mg/l. Summer levels ranged from 3-6 mg/l in the upper reaches of the East Poplar but were somewhat higher in the remainder of the drainage. A fish kill occurred in the East Poplar during the winter of 1977-78 presumably due to low levels of dissolved oxygen (Stewart 1978).

Distribution and Abundance: The distribution of fish species in the Poplar River Basin is shown in Annex 14. In Montana walleye occupy the entire drainage with the exception of the upper half of the West Poplar. Northern pike are widespread with the exception of the upper half of the West Poplar.

The density of all age groups of walleye in the upper East Poplar was low with an estimate of 14 per km (23 per mi). Estimates of walleye in the lower East Poplar ranged from 400 per km (644 per mi) in 1976 to 110 per km (160 per mi) in 1977 (Stewart 1978). The 1977 estimate for all age groups of northern pike was 123 per km (76 per mi). An estimate of walleye in the Poplar River made in 1977 indicated 173 per km (276 per mi) (Stewart 1978).

Spawning walleye and pike were captured throughout the entire length of the Poplar River, except the upper West Poplar where game fish were absent. Walleye were observed spawning over most riffles. Estimates of young-of-the-year walleye in 1977 indicate successful spawning of this species in all portions of the river except the East Poplar. Recapture of marked fish revealed populations were sedentary.

Resource Utilization: Resident fishing license sales in Daniels County, Montana totalled 352 in 1976 (J. Posewitz personal communication). This is only a measure of interest in the sport as it is not known if all licensees pursue their sport exclusively on the Poplar River. Data on unlicensed fishermen (Indians and residents under the age of 15 years) were not available; therefore, this measure of resource utilization is incomplete, and probably underestimates the actual use. Currently, six commercial bait dealers operate on the Poplar River but estimates of their harvest are unknown (J. Posewitz personal communication).

Summary: The fish resource in the Poplar River is diverse with more species present in the lower reaches. Populations of walleye and northern pike are substantial and self-sustaining, which is unusual considering the apparent marginal conditions under which they live. The degree of resource utilization is difficult to assess.

C. Assessment of Potential Impact on Resource

This assessment is applicable to the scenario of one or two units and a reservoir on the East Poplar River as well as the scenario including apportionment as recommended by the Poplar River Task Force (1976). The major effects of the project are due to decreased stream flows. Differences in effects on fish populations between one and two units are small.

1. Stream Morphology: The channel forming flow, that is the flow that maintains pools and riffles along the river, commonly occurs two years out of three (Andrews 1979). The channel forming flow of about 17.5 m^3/sec (620 cfs) in the East Poplar River, will be reduced to between 3 and 7 m^3/sec (105 and 245 cfs) with one power plant and between 2 and 4 m^3/sec (70 and 140 cfs) with two power plants (Andrews 1979). Reduction in the magnitude of channel forming discharges on the Poplar River will be less. Reduced flows will lead to degradation of pools and riffles in the East Poplar River. A lesser effect is expected in the Poplar River. These pool-riffle changes will be gradual in both streams.

Changes in stream morphology below the confluence of the East Poplar and Poplar River will be less due to the accretion of water from the West and Poplar rivers.

Habitat in the upper East Poplar River is unsuitable for the maintenance of game fish populations; therefore, the impact here will be minimal. Game fish are known to spawn successfully in the lower East Poplar River and the Poplar River. Walleye, in particular, utilize the riffles. Predicted reduced flows will result in decreased riffle areas (i.e. spawning substrate) in the East Poplar River and a subsequent loss of walleye production is expected throughout the life of the project.

2. Stream Flow: Year class strength of walleye and northern pike may be positively correlated with stream flows during spawning. Spring runoff increases flows resulting in greater water depth providing flooded terrestrial vegetation preferred by pike as spawning habitat (Machniak 1975a). This increased flow also provides a suitable current over gravel beds utilized by spawning walleye (Machniak 1975b). Sufficient water depth must be maintained throughout incubation and hatching to prevent stranding of eggs and larvae. This critical period occurs during the months of April and May in the Poplar River. Predicted reduced flows will adversely affect walleye and northern pike spawning success in the lower East Poplar River. Effects on the fish in the Poplar River under full apportionment are expected to be less.

3. TDS: An increase in TDS is predicted; the greatest changes will occur in the East Poplar (Surface Water Quality Committee 1979). These predicted levels will be well below the maximum acceptable levels for walleye and northern pike spawning. Therefore, detrimental effects on spawning of game fish should be nil. Similarly, no effects are anticipated for the Poplar River.

4. Changes in Temperature: Two critical time periods when water temperature may adversely affect fish populations are during spawning in April and May and mid-summer when water temperatures approach stress levels for game fish. A sudden release of warm water from the reservoir during April or May is possible (Poplar River Task Force 1976). Rapid temperature fluctuations are known to disrupt walleye spawning and in some cases walleye leave the spawning grounds and resorb their eggs (Derback 1947 and Schumann 1964, cited from Machniak 1975b). If large quantities of warm water from the reservoir are released during this critical time period walleye spawning success could be drastically reduced, and possibly a year class could be eliminated in the East Poplar. Effects in the Poplar River would not be as severe. The Surface Water Quality Committee (1979) indicated summer water releases from Cookson Reservoir would not greatly elevate water temperatures in the East Poplar. However, when midsummer water temperature is near the upper lethal limits for walleye and pike, a discharge of warm water from the reservoir could result in a fish kill on the East Poplar. We are unsure whether temperature elevation will occur.

5. Dissolved Oxygen (D.O.): Data prior to construction of the reservoir are lacking but more recent data indicate that present levels are marginal to sustain existing game fish populations in the East Poplar River in late winter. Indeed, dissolved oxygen levels were low enough to account for the fish kill observed in 1978 (Stewart 1978). Surface Water Quality Committee (1979) predicted that dissolved oxygen in the East Poplar River will not be greatly affected by plant operation. However, even a slight reduction in East Poplar River D.O. levels during winter and midsummer will increase the frequency of fish kills since D.O. levels are aleady critically low during these time periods (Stewart 1978). Dissolved oxygen levels in the Poplar River are not as low as in the East Poplar. Small changes in D.O. here would be less likely to cause fish kills.

6. Changes in Other Water Quality Parameters: Parameters discussed here are metals, nutrients, turbidity and pH. Predicted changes in metals, nutrients and turbidity (Surface Water Quality Committee 1979) should not affect fish populations in the East Poplar River and Poplar River.

The recorded range of pH in the East Poplar River at the International Border was 7.1 to 9.1 (USGS 1975, 1976). A range of 6.5 to 9.0 was suggested as being adequate to protect aquatic life (Great Lakes Water Quality Board 1976). Since existing pH values are near this maximum suggested safe level in some portions of the river, and summer increases in pH are predicted due to increased macrophytes, pH in the East Poplar River may present problems for some fish species. It is less likely to affect fish in the Poplar Rvier.

7. Effects on Other Fish Species: This assessment has considered effects on walleye and northern pike only. These species are the most heavily utilized (for recreational purposes) in the Poplar River. Their

distribution is widespread throughout the river and they are sensitive to environmental changes. Data gathered through fishery research are mainly for these species. Many other fish species dwell in the Poplar River (Annex 14). However, a paucity of data on their life history, distribution and abundance precludes a realistic assessment of impact due to the SPC Coronach Project. Suffice it to say that changes in the Poplar River as a result of the project will no doubt affect other fish species. Predicted changes in water quality and quantity with resultant impacts on aquatic plants and invertebrates will affect forage fish species. Changes in the abundance of forage fish will, in turn, affect the walleye and northern pike which feed upon them.

D. Summary of Impact Predictions

1. Predicted changes in stream morphology will consist of a significant reduction in size of pools and riffles resulting in a loss of game fish production throughout the life of the project. Effects will be most pronounced in the East Poplar River, and will be less in the Poplar River.

2. Reduced flow will adversely affect the walleye and northern pike spawning success in the lower East Poplar River.

3. Predicted increases in TDS are minimal and will not affect fish populations.

4. If warm water is released during April or May it will affect spawning in the East Poplar River. Warm water releases during midsummer could be lethal to game fish in the East Poplar River.

5. Any slight reductions of D.O. in the East Poplar River could cause fish kills.

6. Predicted changes in metals, nutrients and turbidity should not affect fish populations. Slight increases in pH due to macrophyte proliferation in the East Poplar River may cause stress in some fish species.

7. For the scenario of one or two units we predict an eventual loss of 75 percent of the walleye population in the lower East Poplar River. Habitat in the upper East Poplar is marginal and supports only 25 percent as many walleye as the lower East Poplar; this upper East Poplar population will be lost entirely. Habitat in the lower East Poplar is predicted to degrade to the extent that it will become similar to the upper East Poplar River, and result in a 75 percent loss of walleye in the lower East Poplar. It is anticipated that the remaining fish population would no longer attract anglers. With full apportionment on the Poplar River, effects on fish populations will be considerably less than those predicted for the East Poplar River.

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F. Personal Communication

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IV. WILDLIFE

A. Introduction

The SPC Coronach Project is anticipated to cause reduction in stream flows and alteration of wildlife habitat. The Poplar River drainage provides habitat for a wide variety of wildlife which form an integral component of the current high quality of human life existing in northeastern Montana.

B. Baseline Information on Resource

1. Methods: The inventory of wildlife in the Poplar River drainage in Montana was begun in April 1977 and continued through 1978. The study was conducted by personnel of the Montana Department of Fish and Game through a U.S. Environmental Protection Agency grant. A comprehensive report presenting findings of this study is scheduled for completion in early 1979 (DeSimone in prep.). Information was collected on all amphibians, reptiles, birds and mammals observed in the area. Intensive inventory studies have focussed on waterfowl populations occurring along the East Poplar and lower Poplar River because: techniques have been developed for their inventory, they occur in measurable numbers, it appeared that duck habitat would be altered due to the SPC Coronach Project, status of waterfowl populations have local, state, national and international significance.

Waterfowl: Waterfowl, observed in the Poplar River drainage were divided into ducks, Canada geese, shorebirds and other waterfowl. Observations of waterfowl during the spring were made in nine aerial surveys from April 7 to June 15, 1977 and six aerial surveys from April 14 to June 9, 1978. These surveys helped determine the extent to which the Poplar River system was used as a stopover and resting area during the northward migration of waterfowl.

During spring 1977, breeding pairs of ducks were inventoried from the air on the East Poplar and lower Poplar River and in spring 1978, this inventory was expanded to the entire Poplar, Coal Creek, Butte Creek and the West Poplar. The breeding pair census followed the techniques outlined by Dzubin (1969).

Duck brood information was collected on the East Poplar and the lower Poplar River from June through August 1977 and 1978. Eighty-four km (52 mi) of river were inventoried on foot, three times each year, and duck broods were recorded according to date, species, number in brood, age class and location. Calculations of brood production, hatching chronology and reproductive success followed the procedures described by Gollop and Marshall (1954).

Waterfowl utilizing the Poplar River system during fall migration were inventoried during four aerial surveys from September 12 to November 9, 1977.

Shorebirds observed during the walking routes along the East Poplar and lower Poplar River in 1978 were recorded according to date, species, group size, age class and location. To establish breeding records vegetation along the river was periodically searched to locate active nests or dependent young.

Other Wildlife: Observations of wildlife other than waterfowl were recorded in 1977 and 1978 during walking, driving and aerial surveys. Observational information included: date, species, sex, group size and location. Wildlife observations were recorded on the East Poplar and lower Poplar River during two walking routes in July and one in August 1977, and monthly from May through August 1978. Ground surveys were conducted throughout the Poplar River drainage during 1977 and 1978. Although the primary objective of aerial surveys was to determine waterfowl utilization of the Poplar River system, wildlife other than waterfowl were also recorded.

2. Results and Discussion:

Waterfowl: Status and abundance of species observed in the Poplar River drainage during 1977 and 1978 are presented in Annex 15.

Ducks: Utilization of the Poplar River system by migrating ducks in the spring was noted soon after the disappearance of ice. On the Poplar River system, spring ice break-up occurred during late March and early April in both 1977 and 1978, but the upper reaches of the East Poplar remained ice-covered approximately two weeks longer.

Although precise records of migration peaks of individual duck species were not possible to compile, it did appear that the migration sequence generally followed that reported by Ellig (1955) for Greenfields Lake, Montana and Keith (1961) for southwestern Alberta. Early migrants included pintails, mallards and American wigeon, followed by canvasback, northern shovelers, common goldeneye, redheads and finally buffleheads, lesser scaup, green-winged teal, blue-winged teal and ruddy ducks. The largest number of ducks observed during one survey in 1977 was on April 26 when over 2500 ducks were recorded and during 1978 on April 14 when over 2200 were recorded. This information indicated that the Poplar River system supported an average of between 6 and 8 ducks per km (10 and 12 per mi) of river during peak spring migration.

Six species of ducks including the mallard, pintail, American wigeon, gadwall, blue-winged teal and northern shoveler were successful in producing broods during 1977. During 1978 the lesser scaup and common merganser were also probable breeders although broods were not observed. The mallard was the most common breeder comprising over 50 percent of all breeding pairs inventoried (Table 5). American wigeon was next, followed by gadwall, pintail, blue-winged teal, northern shoveler, lesser scaup and

Table 5. Estimated number of breeding pairs of ducks, according to species and breeding pair densities, on the East Poplar and lower Poplar River during spring 1977, and on the Poplar River system during spring 1978.

	1977				1978							
	East Poplar (34.3)[1]	Lower Poplar (50.5)	Total (84.8)	Percent	East Poplar (34.3)	Lower Poplar (50.5)	Upper Poplar (59.5)	Coal Creek (20.5)	Butte Creek (51.7)	West Poplar (112.4)	Total (329.2)	Percent
Mallard	71	91	162	62.8	61	76	106	17	48	78	386	52.4
American wigeon	18	19	37	14.4	30	31	37	4	13	37	152	20.6
Pintail	12	9	21	8.1	19	10	12	2	3	21	67	9.1
Gadwall	6	12	18	7.0	24	15	20	1	8	22	90	12.2
Blue-winged teal	4	9	13	5.0	3	5	4	1	1	5	19	2.6
Northern shoveler	4	3	7	2.7	3	3	5		3	3	17	2.3
Lesser scaup					1		1			1	3	0.4
Common merganser					1					2	3	0.4
TOTAL	115	143	258	100	142	140	185	25	76	169	737	100
Density (pair/km)	3.35	2.83	3.04		4.14	2.77	3.09	1.22	1.47	1.50	2.24	

[1] Number of km inventoried.

common merganser. The highest density of breeding pairs occurred on the East Poplar, followed by the upper Poplar, lower Poplar, West Poplar, Butte Creek and Coal Creek. A total of 737 breeding pairs was estimated for the 330 km (205 mi) of waterway inventoried, indicating an overall average of 2.2 breeding pairs per km (3.6 per mi). Comparison of 1977 and 1978 data indicates that the number of breeding pairs of ducks remained relatively stable on the lower Poplar River (Table 5), while there was a 15 percent increase in the number of breeding pairs on the East Poplar.

Hatching extended over a 102-day period in 1977 and 91-day period in 1978 (Table 6). The hatching chronology for all duck species combined was similar in both years, when approximately one-half the broods hatched during the June 11 through July 10 period. Mallards and pintails were early nesters, followed by American wigeon, northern shovelers, blue-winged teal and gadwalls.

The inventory of duck broods on the East Poplar and lower Poplar River indicated an overall two-fold increase in the number of ducklings produced to flight; in 1977 an estimated 5.4 ducks per km (8.7 per mi) were reared to flight, while in 1978 this increased to 10.9 ducks per km (17.5 per mi) for the 84.8 km (52.7 mi) inventoried. This rise in production was a result of increases in the number of breeding pairs (9 percent), reproductive success (21 percent), the number of broods (28 percent) and brood survival (32 percent). The increases in duck population during 1978 were related to the availability of brood cover in and along the river. Precipitation was below average from January through July 1977, resulting in cattle concentrating near the river for water and forage. During the dry conditions of 1977, much of the shoreline and emergent vegetation was either used as forage or destroyed through trampling by cattle. During the latter part of 1977 and early 1978 above average precipitation produced more favorable pastureage resulting in cattle being more dispersed thereby allowing shoreline and emergent vegetation to develop.

The percentage of hens successful in raising a brood (reproductive success) increased from 44.8 percent in 1977 to 57.1 percent in 1978. Keith (1961) reported the results of 10 waterfowl studies conducted in the Canadian prairies and the Dakotas which indicated that a mean of 49 percent of the hens were successful in raising a brood. Reproductive success in excess of 70 percent was reported in waterfowl studies on stock watering ponds in eastern Montana (Smith 1953; Gjersing 1971; Mundinger 1975).

The average brood size for all six species of ducks combined on the Poplar River increased from 4.43 in 1977 to 6.49 in 1978 (Table 7). Data for these same species from combined North American waterfowl production studies (Bellrose 1976) showed lower Class I and Class III average brood sizes, but higher Class II sizes than the 1978 Poplar River data, although the overall average brood size was similar (6.51).

The upper reaches of the East Poplar provided better duck habitat than the other portions studied (Table 8). Emergent vegetation was more abundant along the upper 14.5 km (9 mi) of the East Poplar and

Table 6. Hatching dates of duck broods observed on the East Poplar and lower Poplar River during 1977 and 1978.

	May 1-10	May 11-20	May 21-31	June 1-10	June 11-20	June 21-30	July 1-10	July 11-20	July 21-31	August 1-10
Mallard										
1977	1[1]/1.8[2]/1.8[3]	6/10.7/12.5	4/ 7.1/19.6	7/12.5/32.1	10/17.9/50.0	4/ 7.1/57.1	17/30.4/87.5	3/ 5.4/92.9	3/ 5.4/98.2	1/ 1.8/100
1978			8/ 7.4/ 7.4	25/22.9/30.3	18/16.5/46.8	29/26.6/73.4	16/14.7/88.1	11/10.1/98.2	2/ 1.8/100	
American wigeon										
1977					4/17.4/17.4	5/21.7/39.1	9/39.1/78.3	5/21.7/100		
1978			2/ 3.7/ 3.7	5/ 9.2/12.9	6/11.1/24.0	13/24.1/48.1	12/22.2/70.3	9/16.7/87.0	7/13.0/100	
Pintail										
1977			1/12.5/12.5	2/25.0/37.5	3/37.5/75.0	1/12.5/87.5		1/12.5/100		
1978	2/16.7/16.7		1/ 8.3/25.0	3/25.0/50.0	1/ 8.3/58.3	4/33.3/91.6	1/ 8.3/99.9			
Gadwall										
1977						1/ 6.3/ 6.3	10/62.5/68.8	5/31.3/100		
1978					2/10.0/10.0	7/35.0/45.0	7/35.0/80.0		4/20.0/100	
Blue-winged teal										
1977						2/20.0/20.0	6/60.0/80.0		1/10.0/90.0	1/10.0/100
1978		1/ 4.0/4.0		2/ 8.0/12.0	1/ 4.0/16.0	1/ 4.0/20.0	15/60.0/80.0	2/ 8.0/88.0	2/ 8.0/96.0	1/ 4.0/100
Northern shoveler										
1977					1/50.0/50.0		1/50.0/100			
1978				1/25.0/25.0	1/25.0/50.0	1/25.0/75.0	1/25.0/100			
Total										
1977	1/ 0.9/ 0.9	6/ 5.2/6.1	5/ 4.3/10.4	9/ 7.8/18.3	18/15.7/33.9	13/11.3/45.2	43/37.4/82.6	14/12.2/94.8	4/ 3.5/98.3	2/ 1.7/100
1978	2/ 0.9/ 0.9	1/ 0.4/1.3	11/ 4.9/ 6.2	36/16.1/22.3	29/13.0/35.3	55/24.6/59.9	52/23.2/83.1	22/ 9.8/92.9	15/ 6.7/99.6	1/ 0.4/100

1 Number of broods hatched during time period.
2 Percentage of total hatch during time period.
3 Cumulative percentage of hatch during time period.

Table 7. Number and average brood size of duck broods observed on the East Poplar and lower Poplar River during 1977 and 1978.

	Class I[1]			Class II[2]			Class III[3]		
	No. Broods	No. Young	Ave. Brood Size	No. Broods	No. Young	Ave. Brood Size	No. Broods	No. Young	Ave. Brood Size
Mallard									
1977	28	143	5.1	37	148	4.0	46	156	3.4
1978	14	97	6.9	34	167	4.9	12	85	7.1
American wigeon									
1977	10	59	5.9	17	72	4.2	12	64	5.3
1978	12	85	7.1	25	164	6.6	4	17	4.3
Pintail									
1977	7	28	4.0	4	17	4.3	3	8	2.7
1978	1	9	9.0	5	29	5.8	1	8	8.0
Gadwall									
1977	11	70	6.4	6	30	5.0	10	48	4.8
1978	6	54	9.0	7	39	5.6	3	38	12.7
Blue-winged teal									
1977	5	29	5.8	2	7	3.5	7	30	4.3
1978	10	70	7.0	9	66	7.3	4	24	6.0
Northern shoveler									
1977	-	-	-	2	9	4.5	1	3	3.0
1978	1	7	7.0	2	16	8.0	1	5	5.0
Total									
1977	61	329	5.4	68	283	4.2	79	309	3.9
1978	44	322	7.3	82	481	5.9	25	177	7.1

[1] Broods from 3 to 17 days old.
[2] Broods from 18 to 40 days old.
[3] Broods from 41 days old to flight.

Table 8. Comparison of estimated breeding pairs of ducks, duck broods, number of young and reproductive success on the upper East Poplar, lower East Poplar and lower Poplar River during 1978.

	Number of Breeding Pairs				Number of Broods				Number of Young				Reproductive Success[4]			
	Upper East Poplar[1]	Lower East Poplar[2]	Lower Poplar River[3]	Percent	Upper East Poplar	Lower East Poplar	Lower Poplar River	Percent	Upper East Poplar	Lower East Poplar	Lower Poplar River	Percent	Upper East Poplar	Lower East Poplar	Lower Poplar River	Total
Mallard	28	33	76	48.9	24	24	26	46.3	118	118	127	39.2	85.7	72.7	34.2	54.0
American wigeon	13	17	31	21.8	16	15	11	26.3	106	99	73	30.0	81.3	88.2	35.5	68.9
Pintail	14	5	10	10.4	4	-	5	5.6	23	-	29	5.6	28.6	-	50.0	31.0
Gadwall	14	10	15	13.9	7	5	2	8.8	39	28	11	8.4	50.0	50.0	13.3	35.9
Blue-Winged teal	3	-	5	2.9	8	3	7	11.3	58	22	51	14.1	100+	100+	100+	100+
Northern shoveler	3	-	3	2.1	1	2	-	1.9	8	16	-	2.6	33.3	100+	-	50.0
Total	75	65	140	100	60	49	51	100	352	283	291	100	80.0	75.4	36.4	57.1
Density (No./km.)	5.0	3.4	2.8		4.0	2.5	1.0		23.5	14.7	5.8					

[1] Upper 15 km (9.3 mi) of East Poplar.
[2] Lower 19.3 km (12 mi) of East Poplar.
[3] 50.5 km (31.36 mi) of Poplar River below the confluence with the East Poplar.
[4] Total broods observed expressed as a percentage of the breeding pairs.

particularly the upper 6.4 km (4 mi) compared to the rest of the Poplar River. According to local residents, this condition along the upper reaches of the East Poplar is historical and is probably a result of hydrological, agricultural and edaphic characteristics of the area. Along the upper reaches of the East Poplar during 1977 and 1978, emergent vegetation was interspersed with open water which offered sufficient cover to conceal duck broods but not so dense a condition as to restrict brood movement. Better duck habitat as a result of the interspersion of open water and emergent vegetation contributed to over twice the density of ducklings per mile (Table 8) on the East Poplar as compared to the main Poplar River.

Aerial surveys indicated that the Poplar River system received substantially more use by migrating ducks during the fall than during the spring. The maximum number of ducks observed during one survey was over 6800 on October 5, 1977, which was almost 2.5 times more than the highest counts during the spring. During 1977 the Poplar River froze over during the early part of November, preventing further use by ducks. The highest density of ducks during fall migration occurred on the upper Poplar with an average of over 28 ducks per km (45 per mi) recorded during three surveys. The second highest density occurred on the West Poplar followed by the East Poplar and lower Poplar River. Butte Creek and Coal Creek received little use by migrating ducks.

The group size of ducks inventoried during the fall indicated that 58 percent of all observed ducks were in groups of 100 or larger. There appeared to be a positive relationship between larger groups of ducks and large pool size, although not all large pools were utilized. Ducks were generally found in large pools which had low banks, a straight configuration and recently harvested wheat nearby.

According to recent work concerning waterfowl migration, an estimated 1.5 to 3 million ducks migrate from the prairie breeding grounds of southcentral Canada through northeastern Montana on the way to their wintering grounds in Texas and Louisiana (Bellrose 1976). The number of these waterfowl which may utilize the Poplar River system as a stopover and resting area is influenced by the following factors: (1) tradition of use (Hochbaum 1955), (2) availability of open water (Bellrose 1976), (3) quantity of water available, (4) weather conditions of the prairie breeding grounds of southcentral Canada, and (5) local weather conditions (Hochbaum 1955).

Canada Geese: The peak of Canada goose spring migration through the Poplar River system was during late March and early April in both 1977 and 1978. Use of the Poplar River system was primarily limited to the upper reaches of the West Poplar, although geese were observed on all segments except the East Poplar during the spring. The maximum number observed during the spring in a survey was on April 7, 1977 when 44 were noted.

Reproduction by geese on the Poplar River system occurred on the upper reaches of the West Poplar. In 1977, between five and nine pairs

were present on the West Poplar during the breeding season, and in 1978 a minimum of three broods were produced, totalling a minimum of nine young.

The Poplar River system received limited use by geese during fall 1977. The 118 geese observed during three surveys were located on the upper reaches of the West Poplar between the town of Richland and the Canadian border. This portion of the river had a series of relatively large pools associated with nearby wheat fields which appeared to attract geese.

Shorebirds and Other Waterfowl: Thirty-six species of shorebirds and waterfowl other than ducks and Canada geese were observed utilizing the Poplar River during 1977 and 1978 (Annex 15). Sixteen of these species were observed only during spring and fall migration. The remaining species were divided into: species for which breeding was confirmed (active nests or dependent young), species for which breeding was not confirmed but was probable (territorial males or pairs located), and species which were nonbreeding summer visitors.

The most abundant shorebirds observed in the Poplar River drainage were spotted sandpipers and killdeers, although willets and marbled godwits were also common. Confirmed breeding was indicated for these species as well as the pied-billed grebe, black-crowned night heron and the American coot. Probable breeders included: American bittern, sora, common snipe, upland sandpiper, California gull, ringed-billed gull, common tern, black tern and American avocet. The double-crested cormorant, great blue heron, long-billed curlew and greater yellowlegs were observed during the summer period, although they probably did not breed in the area.

From May through August 1978, over twice the density of shorebirds per km was observed on the lower Poplar River (6.5) as compared to the East Poplar (2.7). The spotted sandpiper and the killdeer accounted for over 60 percent of all shorebirds observed and had densities of over 2.5 per km (4 per mi) on the lower Poplar, compared to about 0.6 per km (less than one per mile) on the East Poplar. These species, as well as the willet and marbled godwit, preferred exposed gravel and sparsely vegetated shorelines (Stewart 1975), which is characteristic of the lower Poplar. The East Poplar had considerably more emergent and shoreline vegetation as compared to the lower Poplar. Species such as the sora, American bittern and black-crowned night heron which prefer stands of emergent vegetation (Stewart 1975) were more common on the East Poplar.

Other Wildlife: The Poplar River drainage provided either seasonal or yearlong habitat for at least 136 species of birds. The status and abundance of each species observed during 1977 and 1978 is given in Annex 15. During walking routes along the East Poplar and lower Poplar River in 1978 the red-winged blackbird was the most commonly observed bird, besides waterfowl and shorebirds. Other birds observed utilizing habitat along the Poplar River included: bank swallow, clay colored sparrow, vesper sparrow, belted kingfisher, common nighthawk and ring-necked

pheasant. Birds associated with grazing land and cropland habitat included: horned lark, meadow lark, chestnut-collared longspur, savannah sparrow, lark bunting, marsh hawk, Swainson's hawk, sharp-tailed grouse and gray partridge. The status and abundance of the 23 mammalian species observed in the Poplar River drainage during 1977 and 1978 is given in Annex 16. The bobcat, sagebrush vole and snowshoe hare may have also occurred in the area, although none were observed. The abundance and distribution of reptiles and amphibians observed during 1977 and 1978 is presented in Annex 17.

The only known endangered species in the Poplar River Basin is the bald eagle which was seen in spring of 1977. Other endangered species which may have occurred in the Basin include black-footed ferrets, northern rocky mountain wolves, peregrine falcons and whooping cranes.

C. Assessment of Potential Impact on Resource

1. Waterfowl:

Ducks: The East Poplar River provided better duck habitat than any other portion of the Poplar River system studied. Information collected during 1977 and 1978 indicated that the highest density of breeding pairs, broods, ducklings and the highest reproductive success occurred on the East Poplar and particularly the upper 14.5 km (9 mi).

The upper reaches of the East Poplar during 1977 and 1978 had emergent vegetation and open water interspersed to the degree that cover was sufficient to conceal duck broods, but not so dense as to restrict brood movement. Studies in Canada and the U.S. have shown that when water surfaces become covered with emergent vegetation the area becomes unsuitable for ducks, compared to areas in which emergents cover less than 50 percent of the water surface (Evans and Black 1956; Stoudt 1971; Whitman 1976). The interspersion of emergent vegetation and open water in the upper reaches of the East Poplar is approaching over 50 percent coverage in some areas. The presence of emergent vegetation in the East Poplar, according to local residents, is historical. The emergents have probably not encroached to the degree of covering the entire water surface in the past, due to periodic flooding which tends to control the growth and spreading of macrophytes.

Under the conditions of a dam and power plant on the East Poplar in Canada, the frequency of flooding will be reduced. This will allow macrophyte growth to continue and eventually cover the entire water surface of the upper reaches of the East Poplar (Aquatic Plants section). Under these conditions, the upper reaches of the East Poplar will be unsuitable for duck production. Eventual losses could be in the order of approximately 70 to 80 breeding pairs of ducks, and the production of between 300 and 400 ducks annually, which is over 50 percent of the annual production of the total East Poplar. Duck habitat in the lower East Poplar probably will not be significantly affected by macrophyte growth similar

to that predicted for the upper East Poplar during the life of the project for three reasons: (i) addition of water from other sources downstream from the International Border, (ii) inherent morphological and floristic differences between the upper and lower East Poplar (more and deeper pools and little existing emergent vegetation on the lower East Poplar), and (iii) increasing influence of cattle grazing in a downstream progression. Without reliable information as to expected flow reductions and other changes to the upper Poplar River it is difficult to predict impacts to existing wildlife populations in this part of the drainage.

Open water in the Cookson Reservoir during fall and winter may cause some waterfowl, particularly ducks, to shortstop their southern migration. However, as only about 100 ducks attempt to overwinter annually on Boundary Reservoir near Estevan in south-eastern Saskatchewan (D. Nieman personal communication), similar in many respects to Cookson Reservoir, the significance of waterfowl shortstopping on the Cookson Reservoir should be minimal. Open water in the ash lagoons should not be used to any extent by waterfowl because of a lack of food and cover. Maintenance of invertebrate populations, periphyton, and macrophyte growth will not be possible because of addition of fly ash to the ash lagoons; consequently bioaccumulation of heavy metals by waterfowl consuming lower trophic organisms concentrating heavy metals will not occur.

Shorebirds: During 1978 the lower reaches of the East Poplar and the main Poplar River supported over twice the abundance and diversity of shorebirds when compared to the upper reaches of the East Poplar. Downstream progression of the morphological, floral and faunal characteristics of the upper reaches of the East Poplar can be expected to result in an eventual decrease in the abundance and species diversity of the shorebirds on the East Poplar. These changes may create habitat for some other shorebird species, although the overall species diversity and abundance can be expected to be reduced.

2. Other Wildlife: The Poplar River drainage provides either seasonal or yearlong habitat for at least 4 species of reptiles and amphibians, 23 species of mammals and over 100 avian species other than waterfowl. Anticipated changes as a result of the power plant may reduce habitat for some of these species, although the overriding factor influencing the abundance, diversity and distribution of these species is primarily land-use practices (farming and grazing).

Impacts are not anticipated for the endangered species although studies have not been made on these animals.

D. Summary of Impact Predictions

Habitat loss due to macrophyte encroachment in the upper East Poplar could result in the eventual loss of approximately 70 to 80 breeding pairs of ducks, and the production of between 300 and 400 ducks annually, which is over 50 percent of the annual production of the total East Poplar.

Habitat changes on the upper East Poplar can be expected to result in an eventual decrease in the abundance and diversity of shorebirds.

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RECOMMENDATIONS

I MEASURES TO REDUCE NEGATIVE IMPACTS IN THE EAST POPLAR RIVER

Installation and operation of Cookson Reservoir and the planned use of water from the East Poplar River in Canada will result in significant changes in the size and shape of this stream. Reductions in peak flows, depth, width, velocities and the loss of habitat will be most apparent. For two units, the East Poplar River at the Border will become 53-68 percent narrower, 42-56 percent shallower and 15-21 percent slower at bankful discharge. These changes will in turn severely affect habitat for certain plant, invertebrate, fish and wildlife species as described in the assessment section of this report.

Table 9 displays water requirements necessary to achieve various biological objectives as well as the consequences of providing these flows. Columns are included that identify the amount of water required and the percent of the average annual discharge of the East Poplar River needed to meet each option. The table was developed by matching the hydrological habitat requirements with known essential biological functions in the East Poplar River. It did not take into account any proposed water apportionment.

Particular significance is attached to the fact that serious consequences are anticipated when relatively minor depletions are considered. Specifically, the entire biological objective can be met with a 92 percent or greater allocation to the U.S., but when the allocation is reduced slightly, to 81 percent, serious biological consequences are predicted. The inescapable conclusion is that the East Poplar River ecosystem represents habitat conditions near the tolerance limits of species studied and can therefore be severely affected by relatively minor hydrological changes.

II MEASURES TO REDUCE NEGATIVE IMPACTS IN THE REMAINDER OF THE POPLAR RIVER

The proposed apportionment (Poplar River Task Force 1976) would allow for 50 percent Canadian usage of the Poplar River; this would result in the increase of rooted aquatic plants, reduction of current-dependent plants and the degradation of habitat for invertebrates, fish and ducks in the Poplar River in Montana. The following measures would be necessary to reduce these effects (presuming apportionment of the East Poplar).

1. Restrict Canada's use of water in the Poplar River Basin to the East Poplar so that flows in the Poplar and West Poplar can continue to be used to maintain the existing productivity of these rivers below the International Boundary.

Table 9. Water requirements for East Poplar River necessary to achieve various biological objectives, and consequences.

Biological Objective	Hydrological Requirements April[1] (m^3/s)	May[1] (m^3/s)	Annual[2] (m^3/s)	Dominant Discharge[3] (m^3/s)	Annual Flow (dam^3)	(AF)	% Mean Annual Flow to U.S.	Biological Consequences
1. 100% restoration of habitat gamefish.	0.4	0.3	0.1	3.5 - 20 (18 d) (2 d)	13,075	10600	92	- as was prior to 1977 i.e. no impact.
2. Maintain channel integrity.	x	x	0.1	3.5 - 20 (18 d) (2 d)	11,457	9288	81	- spawning and rearing will not occur most years. - good for wildlife, plants and invertebrates. - therefore affords some reduction in impact, but not much for some fish.
3. Maintain gamefish spawning and rearing and adult survival.	0.4	0.3	0.1	x	3,873	3140	27	- severe degradation of most habitat and therefore most of the naturally reproducing gamefish populations over project life. - no lessening of impacts on wildlife, plants and invertebrates.

. . . (Cont'd.)

Table 9. (Cont'd.)

Biological Objective	Hydrological Requirements: April[1] (m^3/s)	May[1] (m^3/s)	Annual[2] (m^3/s)	Dominant Discharge[3] (m^3/s)	Annual Flow (dam^3)	Annual Flow (AF)	% Mean Annual Flow to U.S.	Biological Consequences
4. Maintain minimum stream flow.	0.1 m^3/s year round			x	2,541	2060	18	- spawning and rearing will not occur in most years. - loss of most of game fish population.

[1]Minimum instantaneous flows at the International Border should not be allowed to drop below 0.4 m^3/s (15 cfs) in April and 0.3 m^3/s (10 cfs) in May.

[2]Minimum instantaneous flows at the International Border should never be less than 0.1 m^3/s (3 cfs) during normal or above-normal water years.

[3]A release or spill of water from Cookson Reservoir with discharge exceeding 3.5 m^3/s (123 cfs) for 18 days and 20 m^3/s (700 cfs) for two days within that period at the International Border; this release should gradually build up to the 20 m^3/s peak and then recede over a period of several days; the release should occur between March 15 and April 5.

2. If a reservoir is constructed on the Poplar River in Canada, regulate all releases primarily to maintain and improve the aquatic habitat in Montana.

III MEASURES TO OFFSET LOSSES IN FISH AND WILDLIFE RESOURCES

The following measures to offset losses in fish and waterfowl production on the East Poplar River are recommended:

1. The purchase or lease of land at Outlet Creek Marsh. This area is located approximately 6.4 km (4 mi) east of the point where the East Poplar River enters the U.S. from Canada (Fig. 2). A portion of this area is already owned by the U.S. Government (National Wildlife Refuge System) and managed primarily for waterfowl production. Outlet Creek marsh is within the Poplar River Basin, and since it straddles the border, development of the area for wildlife will also benefit Canada. Acquisition or lease of 370 hectares (914 acres) in Montana is necessary to implement a wildlife development plan, according to personnel from Medicine Lake National Wildlife Refuge. The development plan would involve raising the water levels to increase the amount of open water in the marsh. The subsequent interspersion of open water and emergent vegetation would provide additional habitat for waterfowl and increase the waterfowl production in the Poplar River drainage. Furbearers would also benefit from the development of this area. The area currently provides habitat for white-tailed deer, pronghorn antelope and sharp-tailed grouse.

2. Dewatering of the East Poplar River due to the installation and operation of Cookson Reservoir will result in the encroachment of emergent vegetation in the river. When these conditions develop, selected portions of land along the East Poplar should be either purchased or leased and managed (through fencing) for wildlife. Such areas would provide important habitat (primarily cover) for ring-necked pheasants and white-tailed deer.

3. The purchase or lease and development of Carrol Dam. This area is located approximately 9.6 km (4 mi) northwest of Plentywood in northeastern Montana (Fig. 3). The area is included in the Plentywood Creek watershed and development would result in a 40 hectare (99 acre) pond which would be primarily managed for fish production and water related recreation.

4. Implementation of a waterfowl habitat development plan on and around Cookson Reservoir. Possible measures include

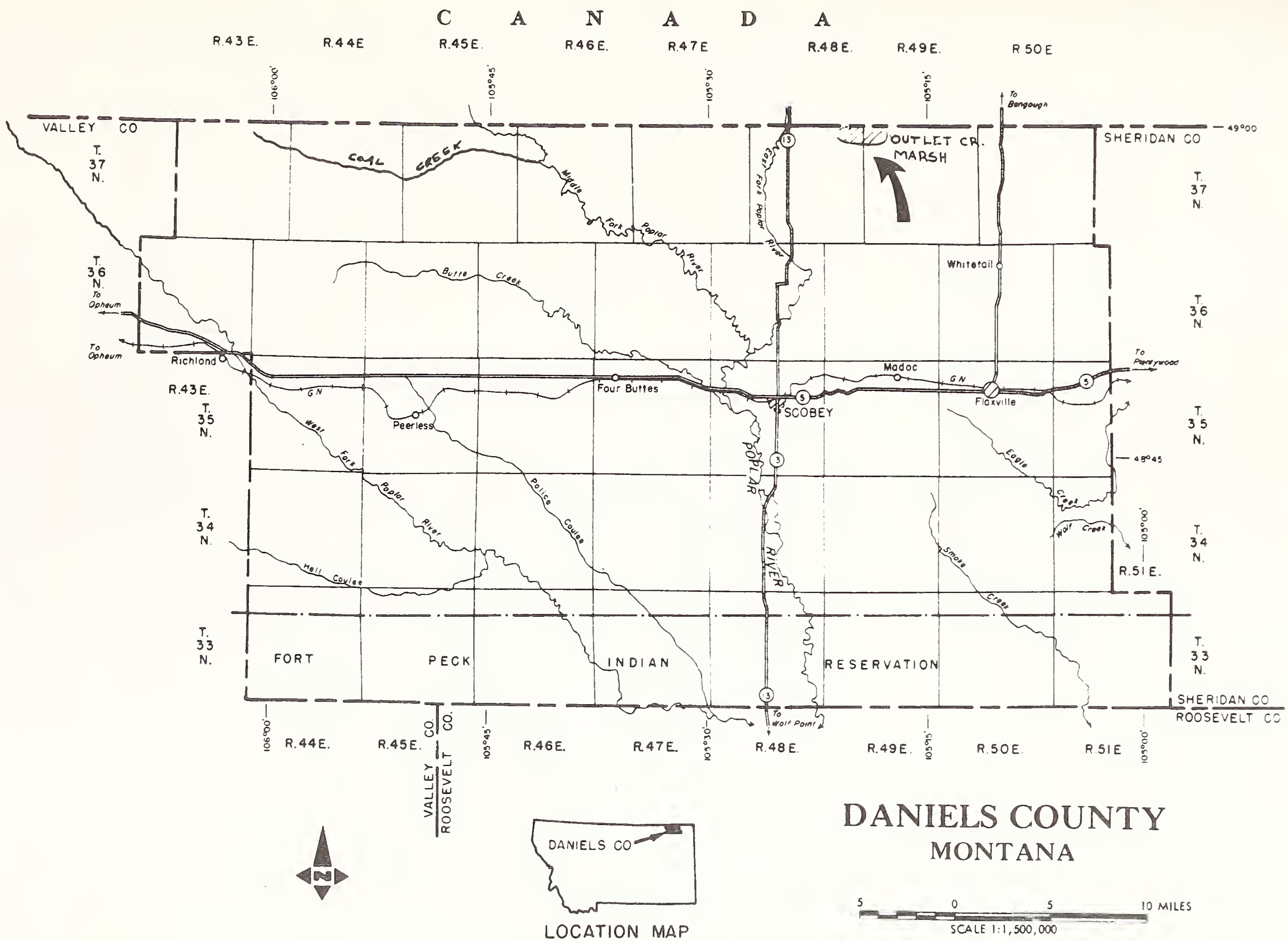

Fig. 2. Location of Outlet Creek Marsh in Montana.

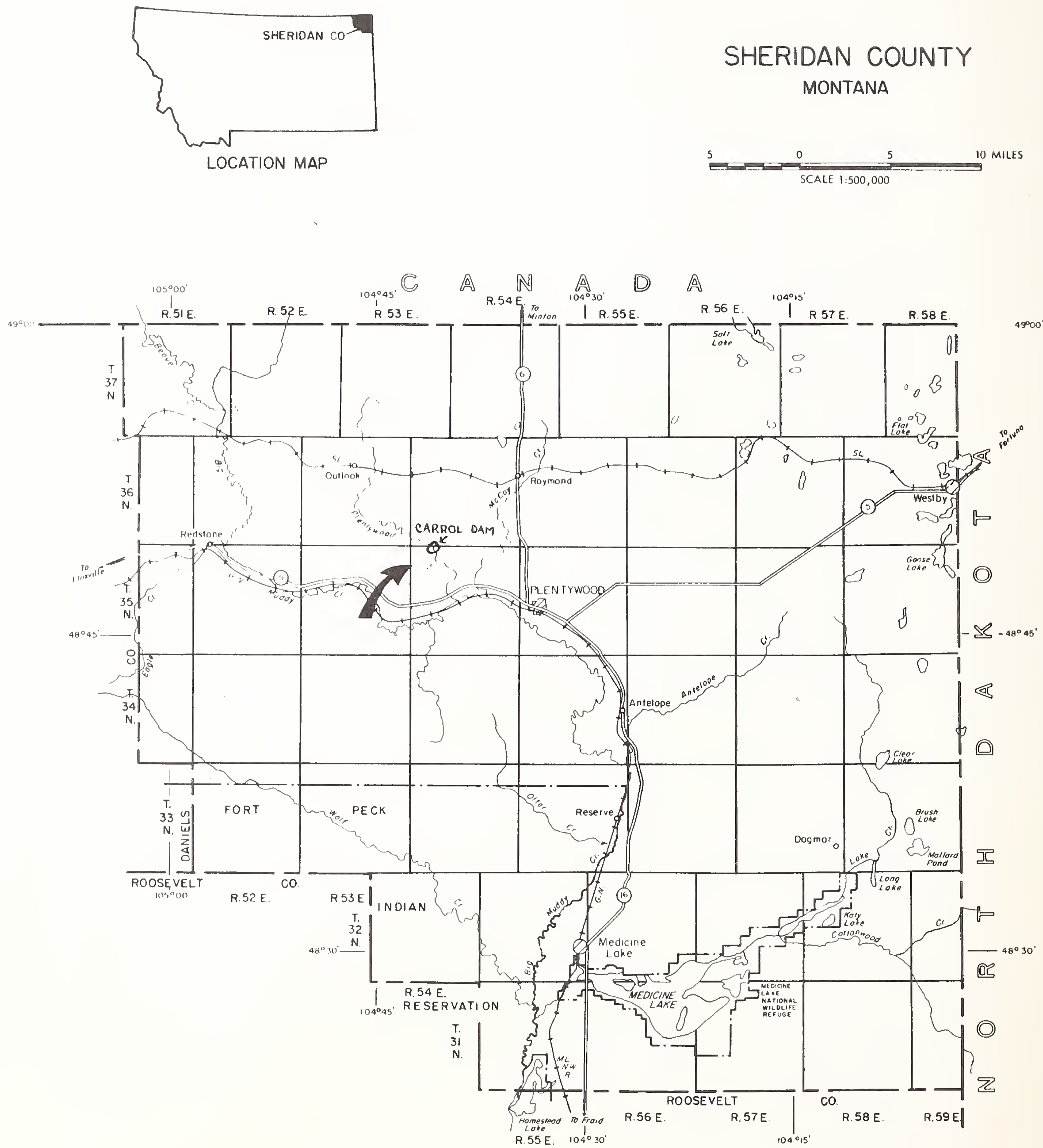

Fig. 3. Location of Carrol Dam in Montana.

fencing the reservoir shoreline to protect waterfowl nesting habitat and diking and constructing islands in the upper or shallower portions of the reservoir. A recognized organization like Ducks Unlimited or a Provincial Wildlife Agency should be contracted to plan and develop management practices.

These measures are intended to offset losses in the East Poplar River and take advantage of wildlife habitat potential in northeastern Montana and Canada. Those measures will not replace the losses in fish or wildlife production in the East Poplar River but they will adequately compensate for these losses in the northeastern area of Montana. Loss of ammenities was a public concern expressed both at the IJC preliminary hearings in Scobey in November 1977 and at our Committee's meeting with area residents in May 1978.

IV RESEARCH AND MONITORING RECOMMENDATIONS

Research and monitoring should be initiated; this should be directed toward measuring the actual impact of the project and filling data deficiencies relative to macrophytes. This knowledge is essential in suggesting changes in project operating procedures and evaluating development options for the Poplar River watershed.

A. Stream Morphology

1. At existing transects (Stewart 1978), monitor stream morphology (width, depth, substrate) in 1980 and every three years thereafter for the project life on the East Poplar with control(s) on the Poplar River.

B. Macrophytes

1. Conduct a rigorous survey of rooted aquatic plants on the East Poplar, to include:

    a) Species composition and estimated relative abundance.

    b) Value to waterfowl and wildlife.

    c) Sensitivity to water level changes.

    d) Establish monitoring transects (same as stream morphology transects where possible) in 1980 and determine existing area of emergent, floating-leaved, and submerged rooted aquatic plants with control(s) on the Poplar River.

2. Monitor macrophyte encroachment and expansion in 1980 and every three years thereafter by:

    a) Aerial (infrared?) photography.

    b) Transects established in B.1.d above.

C. <u>Benthic Invertebrates</u>

1. Establish benthic invertebrate sampling stations (at or near stream morphology transects) in 1980 and gather quantitative and qualitative samples every two years thereafter on East Poplar with control samples from the Poplar River above its confluence with the East Poplar.

D. <u>Fish</u>

1. On all three forks of the Poplar River to the mouth of the West Poplar River:

    a) Document game fish spawning every two years.

    b) Assess larval fish density every two years.

    c) Determine fall populations of young of year and adults.

    d) Analyze tissues of game fish for heavy metals every three to four years after plant operation begins.

E. <u>Ducks</u>

1. Inventory waterfowl use on East Poplar with control on Poplar River between East Poplar and West Poplar utilizing techniques discussed in DeSimone (in prep.):

    a) Annually for breeding pairs.

    b) Every three years for broods.

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ANNEXES

Annex | Page

Annex 1. General habitat and geographical distribution of algae in the Poplar River system, Saskatchewan and Montana (Bahls 1977; Cullimore 1976; Saskmont 1978).

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River	
					Can	US
CHLOROPHYTA (Green Algae)	50 Genera	61 Species	63 Varieties			
Actinastrum	X				X	
A. hantzschii	X				X	
Ankistrodesmus	X	X	X	X	X	X
A. falcatus	X				X	
A. fractus	X				X	
Chlamydomonas	X	X			X	X
Chlorella	X	X	X		X	X
Chlorococcum	X				X	
Cladophora		X	X	X	X	X
Closteriopsis	X				X	
C. longissima	X				X	
Closterium	X	X	X	X	X	X
Coelastrum	X				X	
C. microporum	X				X	
Cosmarium	X	X	X	X	X	X
C. punctulatum	X				X	
Curicigenia quadrata	X				X	
Dactylococcus	X				X	
Dictyosphaerium	X				X	
Dimorphococcus	X				X	
Elakatothrix	X				X	
E. gelatinosa	X				X	
Eudorina elegans	X				X	
Franceia	X				X	
Geminella	X				X	
Gloeocystis	X				X	

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River Can	E. Poplar River US
G. gigas	X				X	
G. major	X				X	
Golenkinia	X				X	
Hormidium	X				X	
Kirchneriella	X				X	
K. subsolitaria	X				X	
Lagerheimia	X				X	
Microspora	X				X	
Micrasterias	X				X	
Mougeotia	X	X	X	X	X	X
Myrmecia	X				X	
Oedogonium		X		X		
Oocystis	X				X	
Palmella	X				X	
Palmellococcus	X				X	
Pandorina morum	X				X	
Pediastrum	X	X	X	X	X	X
P. boryanum	X				X	
P. duplex	X				X	
P. duplex var. chlathratum	X				X	
P. kawraiskyi	X				X	
Phacotus	X				X	
Phytoconis	X				X	
Quadrigula	X				X	
Q. chodatii	X				X	
Q. closterioides	X				X	
Rhizoclonium	X	X		X	X	X
R. hieroglyphicum	X				X	

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River	
					Can	US
Scenedesmus	X	X	X	X	X	X
S. arcuatus var. platydisca	X				X	
S. bijuga	X				X	
S. bijuga var. flexuosus	X				X	
S. dimorphus	X				X	
S. opoliensis	X				X	
S. quadricauda	X				X	
Schroederia	X	X			X	X
Selenastrum	X	X		X	X	X
S. gracile	X				X	
Sphaerocystis	X	X		X	X	X
Spirogyra	X	X	X	X	X	
Staurastrum	X				X	
Stichococcus	X				X	
Stigeoclonium		X	X	X	X	X
Tetraedron	X				X	
T.minimum	X				X	
T. muticum	X				X	
T. trigonum var. gracile	X				X	
Tetraspora		X				X
Tetrastrum	X				X	
Ulothrix	X	X	X		X	X
U. subtilissima	X				X	
Zygnema		X	X			
EUGLENOPHYTA (Euglenoid Algae)	4 Genera	4 Species	4 Varieties			
Euglena	X	X	X	X	X	X

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River Can	E. Poplar River US
Lepocinclis	X				X	
Phacus	X	X		X	X	X
Trachelomonas	X				X	
CHRYSOPHYTA (Golden-Brown Algae)	46 Genera	180 Species	215 Varieties			
Xanthophyceae						
Botryococcus	X				X	
Ophiocytium	X				X	
Tribonema	X				X	
Chrysophyceae						
Dinobryon		X	X	X		X
D. sociale	X				X	
Bacillariophyceae (Diatoms)						
Achnanthes exigua		X	X			
A. hauckiana		X	X	X		
A. hauckiana var. rostrata		X		X		
A. lanceolata		X	X	X		X
Achnanthes linearis		X	X	X		X
A. minutissima		X	X	X		X
A. pinnata		X	X			
A. wellsiae		X				X
Actinella	X				X	
Amphipleura pellucida		X	X	X		X
Amphora		X			X	
A. coffeiformis		X	X	X		
A. ovalis	X	X	X	X	X	X
A. ovalis var. affinis		X	X	X		X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River Can	E. Poplar River US
A. ovalis var. pediculus		X	X	X		X
A. perpusilla		X				X
A. veneta		X	X	X		X
Anomoeoneis sphaerophora		X	X			X
Asterionella	X				X	
Bacillaria paradoxa		X	X	X		X
Caloneis amphisbaena		X		X		X
C. bacillum		X	X	X		X
C. lewissii		X	X	X		
C. ventricosa var. alpina		X				X
C. ventricoas var. truncatula		X				X
Chaetoceros	X				X	
Cocconeis pediculus		X	X	X		X
C. placentula		X	X	X		X
Cyclotella	X	X			X	
C. glomerata	X				X	
C. meneghiniana		X	X	X		X
Cymatopleura elliptica		X	X	X		X
C.solea	X	X	X	X	X	X
Cymbella	X	X			X	
C. affinis	X	X	X		X	X
C. aspera		X	X			
C. cistula		X	X	X		X
C. cistula var. gibbosa		X				X
C. cymbiformis		X		X		X
C. inaequalis		X				X

Taxon	Habitat: Plankton	Habitat: Periphyton	Distribution: West Poplar River	Distribution: Poplar River	Distribution: E. Poplar River Can	Distribution: E. Poplar River US
C. mexicana		X	X	X		X
C. microcephala		X	X	X		X
C. minuta		X	X	X		X
C. muelleri		X	X	X		X
C. pusilla		X				X
C. sinuata		X	X	X		
C. triangulum		X	X	X		
Denticula		X	X			
Diatoma hiemale var. mesodon	X					X
D. tenue		X	X	X		X
Diatomella	X				X	
Diploneis		X			X	
D. oblongella		X		X		
D. puella		X	X	X		X
D. smithii		X		X		
Entomoneis	X				X	
Entomoneis ornata		X		X		X
E. paludosa		X	X	X		X
Epithemia adnata var. minor		X	X	X		X
E. emarginata		X		X		
E. sorex		X	X	X		X
E. turgida		X	X	X		X
E. turgida var. granulata		X	X	X		X
Fragilaria	X				X	
F. brevistriata		X				X
F. brevistriata var. capitata		X		X		X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River	
					Can	US
F. brevistriata var. inflata		X	X	X		X
F. capucina		X				X
F. capucina var. mesolepta		X				X
F. construens		X	X			X
F. construens var. binodis		X	X			X
F. construens var. pumila		X				X
F. construens var. venter		X	X	X		X
F. crotonensis	X	X	X	X	X	X
F. pinnata		X				X
F. pucina	X				X	
F. vaucheriae		X	X	X		X
F.vaucheriae var. #1		X	X	X		
F. sp. #1		X		X		
Frustulia		X			X	
Gomphoneis herculeana		X	X	X		X
G. herculeana var. robusta		X		X		X
Gomphonema	X	X			X	
G. abbreviatum	X				X	
Gomphonema acuminatum	X	X		X	X	
G. angustatum		X	X	X		X
G. brebissonii		X				X
G. constrictum	X				X	
G. dichotomum		X	X	X		X
G. intricatum		X	X	X		X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River	
					Can	US
G. olivaceum		X	X	X		X
G. olivaceum var. calcarea		X	X			
G. parvulum		X	X	X		X
G. tergestinum		X	X	X		X
G. truncatum		X				X
Gyrosigma	X	X			X	
G. spencerii		X	X	X		X
Hantzschia	X	X			X	
H. elongata		X				X
Mastogloia elliptica		X	X			
M. eliptica var. danseii		X	X	X		X
M. e. var. danseii fo. subcapitata		X	X			
M. grevillei		X	X			
M. smithii		X	X	X		X
M sp. #1		X	X			
Melosira	X				X	
Meridion	X	X			X	
M. circulare	X				X	
Navicula	X	X			X	
Navicula accomoda		X	X	X		
N. anglica var. subsalsa		X		X		
N. arvensis		X	X	X		X
N. atomus		X	X	X		X
N. auriculata		X				X
N. capitata		X	X	X		X
N. capitata var. hungarica		X	X	X		X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River Can	E. Poplar River US
N. cincta		X				X
N. cincta var. rostrata		X	X	X		X
N. circumtexta		X	X	X		X
N. cocconeiformis		X		X		
N. cryptocephala		X	X	X		X
N. cryptocephala var. veneta		X	X	X		X
N. cuspidata	X	X	X	X	X	X
N. elginensis		X				X
N. exigua var. capitata		X		X		
N. graciloides		X	X	X		X
N. heufleri		X				X
N. integra		X				X
N. lanceolata		X	X	X		
N. minima		X		X		X
N. minuscula		X				X
N. mutica var. cohnii		X		X		
N. oblonga		X	X			X
N.odiosa		X		X		
N. peregrina		X	X	X		X
N. pupula		X	X	X		X
Navicula pupula var. rectangularis		X		X		
N. pygmaea		X		X		X
N. radiosa		X	X	X		X
N. radiosa var. parva		X		X		
N. radiosa var. tenella		X				X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
			West Poplar River	Poplar River	E. Poplar River	
	Plankton	Periphyton			Can	US
N. salinarum		X				X
N. salinarum var. intermedia		X				X
N. secreta var. apiculata		X	X	X		X
N. tenelloides		X				X
N. tenera		X		X		
N. tripunctata		X	X	X		X
N. viridula		X		X		X
N. viridula var. avenacea		X		X		
N. viridula var. linearis		X		X		
N. viridula var. rostellata		X	X	X		X
N. sp. #1		X		X		
N. sp. #2		X		X		
N. sp. #3		X	X			
N. sp. #4		X		X		
N. sp. #5		X	X	X		
Neidium bisulcatum var. baicalense		X	X			X
N. iridis		X				X
N.iridis var. ampliatum		X		X		
Nitzschia	X	X			X	
N. acicularis	X	X	X	X	X	X
N. acuta		X	X	X		X
Nitzschia amphibia		X	X	X		X
N. angustata		X		X		
N. angustata var. acuta		X	X			X
N. apiculata		X	X	X		X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
			West Poplar River	Poplar River	E. Poplar River	
	Plankton	Periphyton			Can	US
N. capitellata		X		X		
N. communis		X	X	X		X
N. denticula		X	X	X		
N. dissipata		X	X	X		X
N. epiphytica		X	X	X		X
N. filiformis		X	X	X		X
N. fonticola		X		X		X
N. frustulum		X	X	X		X
N. frustulum var. subsalina		X	X	X		X
N. gracilis		X	X	X		X
N. holsatica		X	X			
N. hungarica		X	X	X		X
N. hybrida		X		X		
N. kutzingiana		X		X		
N. linearis		X	X	X		X
N. longissima var. reversa		X				X
N. microcephala		X	X	X		X
N. palea		X	X	X		X
N. paleacea		X	X	X		X
N. recta		X		X		X
N. romana		X	X	X		
N. sigma		X		X		
Nitzxchia sigmoidea		X	X	X		X
N. tryblionella		X		X		X
N. tryblionella var. debilis		X	X	X		
N. tryblionella var. levidensis		X		X		X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River Can	E. Poplar River US
N. tryblionella var. victoriae		X	X	X		X
N. valdestriata		X	X	X		X
N. vermicularis		X				X
N. sp. #1		X		X		
Opephora	X				X	
Pinnularia	X	X			X	X
P. microstauron		X	X	X		X
Plagiotropis lepidoptera	X				X	
P. lepidoptera var. proboscidea		X		X		
Pleurosigma delicatulum		X	X	X		X
Rhoicosphenia curvata	X	X	X	X	X	X
Rhopalodia	X				X	
R. gibba		X	X	X		X
R. musculus		X	X	X		X
Stauroneis phoenicenteron		X				X
Stephanodiscus dubius		X				X
S. minutus		X	X	X		X
Surirella	X	X			X	
S. angustata		X	X	X		X
S. iowensis		X	X	X		X
S. ovata	X	X	X	X	X	X
Surirella ovata var. pinnata		X	X	X		X
S. spiralis		X		X		X
S. tenera		X	X			
Synedra	X	X			X	
S. acus		X				X

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River	
					Can	US
S. delicatissima		X	X	X		
S. famelica		X				X
S. fasciculata		X	X	X		X
S. fasciculata var. truncata		X				X
S. pulchella		X				X
S. radians		X	X	X		X
S. ulna		X	X	X		X
S. ulna var. contracta		X				X
S. sp. #1		X	X			
Tabellaria	X				X	
T. fenestrata	X	X			X	X
PYRROPHYTA	1 Genus	1 Species	1 Variety			
Dinophyceae						
(Dinoflagellates)						
Peridinium	X				X	
CYANOPHYTA (Blue-Green Algae)	21 Genus	26 Species	26 Varieties			
Agmenellum (Merismopedia)	X	X	X	X	X	X
A. glauca	X				X	
Anabaena	X	X	X	X	X	X
A. augstumalis var. marchica	X				X	
A. flos-aquae	X				X	
Anabaena helicoidea	X				X	
Anabaenopsis	X				X	
Anacystis	X				X	
Aphanizomenon	X				X	

Annex 1. (Cont'd.)

Taxon	Habitat		Distribution			
	Plankton	Periphyton	West Poplar River	Poplar River	E. Poplar River Can	E. Poplar River US
A. flos-aquae	X				X	
Aphanocapsa						
A. rivularis	X				X	
Aulosira	X				X	
Chondrocystis		X		X		
Chroococcus	X				X	
Coelosphaerium	X				X	
Gloeocapsa	X				X	
Gloeotrichia		X		X		
Gomphosphaeria	X	X	X	X	X	X
G. lacustris	X				X	
Lyngbya	X	X			X	
Microcystis	X				X	
M. aeruginosa	X				X	
Oscillatoria	X	X	X	X	X	X
O. limnetica	X				X	
O. tenuis	X				X	
Phormidium		X	X	X		X
Rivularia		X	X	X		X
Spirulina	X	X			X	X
S. laxa	X				X	
Spirulina major	X				X	
S. nordstedtii	X				X	
Synechococcus	X				X	
Synechocystis	X				X	
TOTAL	122 Genera	272 Species	309 Varieties			

NOTE: The "Poplar River" includes the "Middle Fork" from the International Boundary to its confluence with the East Poplar River, thence to its mouth at the town of Poplar. All algae from the West Poplar River and the Poplar River were collected from the periphyton community on the U.S. side of the border.

Annex 2. Diatom proportional count for the East Poplar River at the International Border May 24, 1978.

Sample No.: 0093D Notebook No.: 5 Page No.: 130

Major or Sub-Major Basin: Missouri-Ft. Peck Minor Basin: 40Q

Water and Location: E. Poplar River at Canadian Border

Community: Periphyton Substrate: Natural

Date: 5-24-78 Collector/Agency: Bahls/WQB Project: Poplar R.

Taxon	Number	Percent Relative Abundance
Navicula cuspidata		t
N. pygmaea	1	0.3
N. Cincta		t
N. secreta var. apiculata	9	2.2
N. pupula	2	0.5
N. cinta var. rostrata	4	1.0
N. cryptocephala var. veneta	10	2.6
Rhoicosphenia curvata	7	1.8
Entomoneis paludosa	1	0.3
Nitzschia palea	72	18.4
N. acicularis	133	33.9
N. linearis	1	0.3
N. frustulum var. subsalina	1	0.3
N. frustulum	3	0.8
N. hungarica		t
Cocconeis pediculus	14	3.6
Gomphonema parvulum	12	3.1
Fragilaria vaucheriae	3	0.8
Cymbella affinis	8	2.0
Synedra ulna	16	4.1
Fragilaria construens var. venter	7	1.8
Surirella ovata		t
Navicula capitata var. hungarica	3	0.8

Annex 2. (Cont'd.)

Taxon	Number	Percent Relative Abundance
N. cryptocephala	1	0.3
Gomphonema olivaceum	4	1.0
Diatoma tenue	2	0.5
Amphora perpusilla		t
Synedra acus	21	5.4
Surirella iowensis		t
Cymbella cymbiformis	2	0.5
Cyclotella meneghiniana	5	1.3
Navicula (tenelloides?)	3	0.8
Amphora ovalis var. affinis	3	0.8
A. ovalis var. pediculus		t
Mastogloia smithii		t
Gomphonema angustatum		t
Fragilaria brevistriata	7	1.8
Cymbella minuta	3	0.8
Surirella (angustata?)		t
Navicula heufleri	3	0.8
Nitzschia dissipata		t
Fragilaria capucina var. mesolepta		t
Caloneis amphisbaena		t
Pinnularia sp.	2	0.5
Cymbella muelleri		t
Navicula integra	1	0.3
Achnanthes minutissima		t
Fragilaria constrens var. binodis		t
Synedra famelica	2	0.5
Nitzschia epiphytica	2	0.5
Caloneis ventricosa var. truncatula	1	0.3
Nitzschia apiculata	1	0.3
N. communis	1	0.3

Annex 2. (Cont'd.)

Taxon	Number	Percent Relative Abundance
N. longissima var. reversa	4	1.0
Fragilaria capucina	6	1.5
Stephanodiscus (dubius?)	6	1.5

Total Taxa: 61 Taxa Counted (s): 45 Cells Counted (N): 392

Diversity: Shannon-Weaver ($\bar{d}$): 3.79 Other: e = 0.44

Additional Taxa:

Synedra fasciculata var. truncata	1	0.3
Nitzschia gracilis	1	0.3
Navicula circumtexta	1	0.3
Caloneis (bacillum?)	1	0.3
Fragilaria construens	1	0.3
	PRA Achnanthes	t
	PRA Nitzschia	56.1

Annex 3. Aquatic (A) and Riparian (R) macrophytes from the East Poplar River Basin in Saskatchewan (Baron 1974; Cullimore 1976; Saskmont 1978).

Family	Genus and Species	Common Name
Equisetaceae		Horsetail Family
(R)	*Equisetum arvense* L.	Common Horsetail
Typhaceae		Cattail Family
(A)	*Typha latifolia* L.	Common Cattail
Sparganiaceae		Bur Reed Family
(A)	*Sparganium eurycarpum* Engelm.	Broad-Fruited Bur Reed
Najadaceae		Pondweed Family
(A)	*Potamogeton filiformis* Pers.	
	P. richardsonii (Benn.) Rydb.	
	P. vaginatus Turcz.	
Alismaceae		Water Plaintain Family
(A)	*Sagittaria cuneata* Sheld.	Arum-Leaved Arrowhead
Graminaceae		Grass Family
(A)	*Beckmannia syzigachne* (Steud.) Fernald	Slough Grass
(R)	*Deschampsia caespitosa* (L.) Beauv.	Tufted Hair Grass
(R)	*Elymus virginicus* L.	Virginia Wild Rye
(A)	*Glyceria grandis* Wats.	Reed Meadow Grass
(R)	*Hordeum jubatum* L.	Wild Barley
(R)	*Poa palustris* L.	Fowl Bluegrass
(R)	*Poa pratensis* L.	Kentucky Bluegrass
(R)	*Spartina gracilis* Trin.	Alkali Cord Grass
(A)	*Spartina pectinata* Link.	
Cyperaceae		Sedge Family
(A)	*Carex atherodes* Spreng.	Awned Sedge
(A)	*Eleocharis acicularis* R. & S.	Needle Rush
(A)	*E. palustris* (L.) R. & S.	Creeping Spike Rush
(A)	*Scirpus americanus* Pers.	Three-square Bulrush
(A)	*S. validus* Vahl.	Softstem Bulrush; Great Bulrush

Annex 3. (Cont'd.)

Family	Genus and Species	Common Name
Juncaceae		Rush Family
(R)	*Juncus balticus* Willd. var. *montanus* Engelm.	Baltic Rush
Liliaceae		Lily Family
(R)	*Smilacina stellata* (L.) Desf.	Star-Flowered Solomon's Seal
Iridaceae		Iris Family
(R)	*Sisyrinchium montanum* Greene	Common Blue-Eyed Grass
Salicaceae		Willow Family
(R)	*Populus balsamifera* L.	Balsam Poplar
(R)	*P. tremuloides* Michx.	Aspen Poplar
(R)	*Salix amygdaloides* Anders.	Peach-Leaved Willow
(R)	*S. interior* Rawlee	Sandbar Willow
(R)	*S. petiolaris* Smith	Basket Willow
Urticaceae		Nettle Family
(R)	*Urtica gracilis* Ait.	Common Nettle
Polygonaceae		Buckwheat Family
(A)	*Polygonum natans*. A. Eaton	Water Persicaria
(R)	*Rumex crispus* L.	Curled Dock
(R)	*R. fennicus* L.	Field Dock
Chenopodiaceae		Goosefoot Family
(R)	*Suckleya suckleyana* (Torr.) Rydb.	Poison Suckleya
Ranunculaceae		Buttercup Family
(R)	*Anemone canadensis* L.	Canada Anemone
(R)	*A. multifida* Poir.	Cut-Leaved Anemone
(R)	*Ranunculus cymbalaria* Pursh	Seaside Buttercup
(R)	*R. macounii* Britt.	Macoun's Buttersup
(A)	*R. sceleratus* L.	Cursed Crowfoot
(R)	*Thalictrum occidentale* A. Gray	Western Meadow Rue
Rosaceae		Rose Family
(R)	*Amelanchier alnifolia* Nutt.	Saskatoon
(R)	*Crataegus chrysocarpa* Ashe	Round-Leaved Hawthorn

Annex 3. (Cont'd.)

Family	Genus and Species	Common Name
Rosaceae (cont'd)		Rose Family
(R)	*Potentilla anserina* L.	Silverweed
(R)	*P. norvegica* L.	Rough Cinquefoil
(R)	*Prunus pennsylvanica* Lf.	Pin Cherry
(R)	*P. virginiana* L. var. *melanocarpa* (A.Nels.) Sarg.	Black-Fruited Choke Cherry
(R)	*Rosa acicularis* Lindl.	Prickly Rose
Leguminosae		Pea Family
(R)	*Glycyrrhiza lepidota* (Nutt.)	Wild Licorice
(R)	*Hedysarum alpinum* L. var. *americanum* Michx.	American Hedysarum
(R)	*Melilotus alba* Desr.	White Sweet Clover
(R)	*M. officianalis* (L.) Lam.	Yellow Sweet Clover
Aceraceae		Maple Family
(R)	*Acernegundo* L. var. *interius* (Britt.) Sarg.	Manitoba Maple
Elaeagnaceae		Oleaster Family
(R)	*Elaeagnus commutata* Bernh.	Wolfwillow
Onagraceae		Evening Primrose Family
(R)	*Epilobium paniculatum* Nutt.	Annual Willow Herb
(R)	*Oenothera biennis* L. var. *canescens.* T. & G.	Western Yellow Evening
Haloragidaceae		Water Milfoil Family
(A)	*Myriophyllum exalbescens* Fernald	Spiked Water Milfoil
Umbelliferae		Parsley Family
(A)	*Sium suave* Walt.	Water Parsnip
(R)	*Zizia aptera* (Gray) Fern	Heart-Leaved Alexanders
Cornaceae		Dogwood Family
(R)	*Cornus stolonifera* Michx.	Red-osier Dogwood
Apocynaceae		Dogbane Family
(R)	*Apocynum sibiricum* Jacq.	Clasping-Leaved Dogbane
Convolvulaceae		Morning Glory Family
(R)	*Convolvulus sepium* L. var. *americanus* Sims	Wild Morning Glory

Annex 3. (Cont'd.)

Family	Genus and Species	Common Name
Polemoniaceae		Phlox Family
(R)	*Phlox pilosa* L.	Downy Phlox
Labiatae		Mint Family
(A)	*Lycopus americanus* Muhl.	Water Horehound
(A)	*Mentha arvensis* L. var. *villosa* (Benth.) S. R. Stewart	Wild Mint
(R)	*Monarda fistulosa* L. var. *menthaefolia* (Graham) Fern.	Western Wild Bergamot
Scrophulariaceae		Figwort Family
(R)	*Penstemon procerus* Dougl.	Slender Beardtongue
Lentibulariaceae		Bladderwort Family
(A)	*Utricularia vulgaris* L. var. *americana* Gray	Greater Bladderwort
Plantaginaceae		Plaintain Family
(R)	*Plantago eriopoda* Torr.	Saline Plantain
Rubiaceae		Madder Family
(R)	*Galliom boreale* L.	Northern Bedstraw
Compositae		Composite Family
(R)	*Agoseris glauca* Pursh.	Large-Flowered False Dandelion
(R)	*Aster pansus* (Blake) Cronquist	Many-Flowered Aster
(R)	*A. pauciflorus* Nutt.	Few-Flowered Aster
(A)	*Bidens cernua* L.	Bur Marigold
(R)	*Brachyactis angusta* (Lindle) Britton	Rayless Aster
(R)	*Hieracium canadense* Michx.	Canada Hawkweed
(R)	*Helianthus petiolaris* Nutts.	Prairie Sunflower
(R)	*Lactuca pulchella* (Pursh) DC.	Blue Lettuce
(R)	*Solidago canadensis* L var. *gilvocanescens*	Canescent Goldenrod
(R)	*S. graminifolia* (L.)var. *major* (Michx.) Fernald	Flat-Topped Goldenrod
(R)	*Taraxacum laevigatum* (Willd.) DC.	Red-Seeded Dandelion
(R)	*T. officinale* Weber	Dandelion

Annex 4

EFFECTS OF REDUCED STREAMFLOWS ON THE HYDRAULIC AND GEOMORPHIC CHARACTERISTICS OF CHANNELS IN THE POPLAR RIVER BASIN, MONTANA

by

Edmund D. Andrews

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INTRODUCTION

The hydraulic and geomorphic characteristics of natural stream channels adjust over a period of years to the particular quantities of water and sediment provided by the watershed. A long-term change in either or both water discharge and sediment load will disturb the existing equilibrium and the stream will adjust in time to the new conditions. The operation of a reservoir and diversion of streamflow alters both the water and sediment discharge in complex ways. Reservoirs reduce the magnitude of peak discharges, decrease the sediment load, and increase the magnitude of small discharges. It is difficult to generalize the consequences of a reservoir upon the channel downstream because the equilibrium adjustment depends upon the combined effect of changes in several variables. In particular, stream channels tend to become smaller as the magnitude of channel-forming discharges is decreased. The release of sediment-free water from a reservoir, however, tends to erode and thus enlarge the stream channel. Both of these changes will occur to various degress downstream of a reservoir. Thus, the specific adjustment of the channel downstream of a reservoir depends upon the relative magnitude of changes in water discharge and sediment load. Ideally, the multiple hydraulic and geomorphic effects of reduced streamflows and sediment loads in streams of the Poplar River basin could be simulated by a water and sediment routing model. Owing to a deficiency of data and the particular hydrological characteristics of the Poplar River basin, however, the several effects of water storage and consumption will be considered separately.

HYDRAULIC GEOMETRY OF STREAM CHANNELS IN THE POPLAR RIVER BASIN

The downstream adjustment of the Poplar River to increasing water and sediment discharge may be described by the technique of hydraulic geometry. Leopold and Maddock (1953) found that the variation of the hydraulic variables, mean velocity ($\bar{u}$), mean depth ($\bar{d}$), and surface width (w), with increasing discharge (Q) downstream could be represented by a set of simple power equations:

$$\bar{u} = a\,Q^{m}$$

$$\bar{d} = c\,Q^{f}$$

$$w = k\,Q^{b}$$

These relations are called the "hydraulic geometry" of the stream. The hydraulic exponents m, f, and b describe the rate of change of the hydraulic variables $\bar{u}$, $\bar{d}$, and w to accommodate greater discharge.

Current-meter discharge measurements and streamflow records collected at 8 gaging stations provide the necessary data for determining the downstream hydraulic geometry of the Poplar River. The hydraulic characteristics,

velocity, depth, and width, of a stream vary with discharge both at a channel cross section and downstream. Thus, in order to make a valid comparison of cross sections along a length of stream, the hydraulic characteristics of the several cross sections must be those associated with a discharge having the same frequency of occurence at all sections. Discharges having a frequency of occurence of between 1 and 2 years on the annual peak flood series are commonly the channel-forming discharges and fill the channel to near the level of the floodplain: ie. the bankfull discharge. Therefore, the discharge having a recurrence interval of 1.5 years, $Q_{1.5}$ yr., is frequently chosen to represent the range of channel-forming discharges, and is a logical basis for comparing the hydraulic characteristics of several cross sections along a reach of stream.

The downstream hydraulic geometry of the Poplar River is shown in Figure 1. Each data point is identified by a number, which refers to a gaging station listed in Table 1. The values of velocity, depth, and width at the several gaging stations have been plotted against their corresponding $Q_{1.5}$ yr. A mean relation line was fit by eye on each graph. The equations of the mean relations are:

$$\bar{u} = 0.60\ Q^{0.11}$$

$$\bar{d} = 0.24\ Q^{0.38}$$

$$w = 6.64\ Q^{0.52}$$

These equations describe the downstream variation of velocity, depth and width of stream channels in the Poplar River basin at their respective 1.5 yr. discharges.

The mean value of hydraulic exponents of streams in the midwestern United States are m=0.10, f=0.40, and b=0.50, Leopold et al. (1964). The downstream hydraulic exponents of the Poplar River are in good agreement with the mean regional values.

The amount of scatter in the data appears to be large, but it is consistent with other areas and to be expected. Along any reach of a stream, there is considerable variation in channel width, depth, slope, roughness, and velocity associated with the pool and riffle sequence and meanders. Studies by Richards (1976) and Andrews (1978) have shown that pool cross sections are narrower, deeper, hydraulically rougher and have flatter water surface slopes than riffles. Riffles and pools appear to be the extremes of a continuous distribution, with most cross sections having intermediate characteristics. The range of variation is commonly a factor of 2 around the mean-values for the reach. These generalizations appear to apply to the Poplar River, though perhaps an even wider range of hydraulic characteristics between riffles and pools may occur. The scatter of observations in Fig. 1 is due to this natural variation. The observations were made at a single cross section, and thus, do not represent the mean condition of stream reach. The approximate mean hydraulic characteristics are shown by the fitted lines.

Table 1. Velocity, depth, and width of flow at Poplar River basin gaging stations for the discharge with a 1.5 year recurrence interval.

Site Number on Fig. 2	Gaging Station Number	Station Name	Drainage Area km^2	Discharge R.I.=1.5 yr. m^3/s	Velocity m/s	Depth m	Width m
1	06178000	Poplar River at International Boundary	937	12.0	0.74	0.80	20.3
2	06178500	East Poplar River at International Boundary	1380	17.5	1.01	0.64	27.1
3	06179000	East Poplar River Near Scobey	1870	16.4*	1.18	0.67	20.8
4	06179500	West Poplar River at International Boundary	360	2.87	0.30	0.33	29.0
5	0618000	West Poplar River Near Richland	1110	8.5	0.81	0.40	26.1
6	06180400	West Poplar River Near Bredette	1900	16.5	0.93	0.64	27.7
7	06180500	Poplar River Near Bredette	7615	53.7	1.06	0.60	84.4
8	06181000	Poplar River Near Poplar	8220	60.6	1.02	1.61	36.9

* based on 6-year record during dry years.

The hydraulic geometry relations describe the downstream variation of velocity, depth, and width associated with a discharge of a common frequency. Consequently, these relations may be used to estimate the change in hydraulic characteristics of a reach resulting from a change in the magnitude of the 1.5 year discharge, which is also approximately the channel-forming discharge. For example, if the magnitude of the channel-forming discharge decreases through a reach of stream, the hydraulic characteristics of the reach will adjust and become similar to the hydraulic characteristics of the reach of channel upstream that previously had that magnitude of channel forming discharge.

The construction of a reservoir and power plant on the East Poplar River will alter the magnitude of discharges and consequently the hydraulic characteristics of the channel. An estimate of the changes in channel characteristics in a given reach of stream can be calculated from the hydraulic geometry relations and the probable magnitude of channel-forming discharges.

The probable monthly streamflows at the International Boundary gaging stations following the operation of Cookson Reservoir and either one or two power plant units have been computed by the Surface Water Quality Committee (1978). The hydraulic characteristics of a stream channel, however, are more closely related to peak discharges than average monthly streamflows. Therefore, it is necessary to estimate the peak discharges which will be associated with these average monthly stream flows. It is possible, however, only to define the peak dishcarges within certain limits. The upper limit is defined by the relation between average monthly streamflow and peak discharge which existed prior to the reservoir and power plant. When this relation is combined with the estimated average monthly streamflows, following construction and operation of the reservoir and power plant unit(s), approximate peak discharges may be computed. These peak discharges approximate the natural peak discharges minus the average depletion for the month plus the average return flow for the month.

There is an additional effect of a reservoir upon peak discharges. Reservoirs tend to flatten or broaden a flood surge. Thus, the peak discharge of a flood surge will be reduced as it passes through a full reservoir even without any depletions. Petts (1977) stated that this reduction in flood peaks would be as much as 50 percent for small reservoirs. Thus, a lower limit on the peak discharges may be estimated by taking 50 percent of the upper limit.

The recurrence intervals of annual peak discharges of the East Poplar River at the International Boundary prior to the reservoir and a one unit power plant are shown by curve A in Fig. 2. The upper limit of peak discharge is shown by curve B and the lower limit by curve C. Figure 2 shows that the 1.5 year discharge will be reduced from 17.5 m^3/sec to a maximum of 7 m^3/sec and perhaps as low as 3 m^3/sec in the East Poplar River at the International Boundary for the reservoir and a one unit power plant. Over a number of years, the stream channel will adjust

to the reduced magnitude of the channel-forming discharges. The percentage change in velocity, depth and width computed by the hydraulic geometry relations is shown in Table 2. Flow in the East Poplar River at the International Boundary will probably become 38 to 60 percent narrower, 30 to 49 percent shallower, and 10 to 17 percent slower at the bankfull discharge.

The probable upper and lower limits of peak discharges in the East Poplar River at the International Boundary with a two unit power plant and reservoir are shown in Fig. 3. The range of peak discharges for a given recurrence interval is only slightly less than for the one unit power plant case. With a two unit power plant, the 1.5 year discharge would probably be between 4.0 m^3/sec and 2 m^3/sec. The percentage change in velocity, depth, and width for the East Poplar River at the International Boundary due to the reduced magnitude of channel-forming discharges associated with the operation of Cookson Reservoir and a two unit power plant are shown in Table 3. Flow in the East Poplar River at the International Boundary will probably become 53 to 68 percent narrower, 42 to 56 percent shallower and 15 to 21 percent slower at the bankfull discharge.

An additional reservoir has been proposed for the Poplar River in order that streamflows may be allocated in accordance with the compact apportionment. Such a reservoir would have similar impacts upon the Poplar River as those described above for the East Poplar River. The probable reduction in annual peak discharges in the Poplar River at the International Boundary was computed in the same manner as described previously, and is shown in Fig. 4. The 1.5 year discharge would likely be reduced from 12 m^3/sec to between 8.5 and 4.4 m^3/sec. As a result, bankfull discharge will probably become 4 to 10 percent slower, 13 to 31 percent shallower, and 17 to 40 percent narrower, Table 4.

Degradation of Stream Bed and Banks

As noted previously, the release of sediment-free water from a reservoir tends to erode and thus enlarge the stream channel immediately downstream of the reservoir. This problem has been considered in detail by Komura and Simmons (1967). Degradation of the stream channel occurs because releases from the reservoir transport bed material sediment downstream, whereas no sediment is supplied from upstream. Commonly, the stream channel is affected by both scour of the bed and erosion of banks. Scour of the stream bed is the most significant effect and depends upon the size of bed material. Typically, some fraction of the bed material is too coarse to be transported by the discharges released from the reservoir. Therefore, the finer particles are eroded from the bed leaving only the coarser particles. At this point, the stream bed is said to be "armored" and no further degradation occurs. Erosion of stream banks depends upon a balance between the boundary shear stress and the cohesiveness of the banks. The percentage of silt and clay in the banks and extent of vegetation are the primary factors giving cohesiveness to the banks.

Table 2. Probable decrease in velocity, depth, and width of flow in East Poplar River at the International Boundary associated with reduced magnitude of the 1.5 year discharge due to Cookson Reservoir and a one unit power plant.

	Percent change with $Q_{1.5}$ = 7 m^3/sec	Percent Change with $Q_{1.5}$ = 3 m^3/sec
Velocity	10	17
Depth	30	49
Width	38	60

Table 3. Probable decrease in velocity, depth, and width of flow in the East Poplar River at the International Boundary associated with a reduced magnitude of the 1.5 year discharge due to Cookson reservoir and a two unit power plant.

	Percent change with $Q_{1.5}$ = 4 m^3/sec	Percent Change with $Q_{1.5}$ = 2 m^3/sec
Velocity	15	21
Depth	42	56
Width	53	68

Table 4. Probable decrease in velocity, depth, and width of flow in the Poplar River at the International Boundary associated with a reduced magnitude of the 1.5 year discharge due to the proposed reservoir.

	Percent change $Q_{1.5}$= 8.5 m^3/ sec	Percent Change $Q_{1.5}$= 4.4 m^3/ sec
Velocity	4	10
Depth	13	31
Width	17	40

The transport rate of bed material depends upon the size of bed material and flow characteristics. Samples of stream bed material were collected at nine locations in the Poplar River basin. At each location, two samples were collected - one each from a pool and riffle. These samples were mechanically sieved to determine the distribution of bed material sizes; the results are summarized in Table 5. The distribution of bed material sizes for the riffle samples are fairly similar throughout the Poplar River basin, although there is a slight decrease in size downstream. These samples, however, were not collected at gaging stations where the streamflow conditions are known. Therefore, two generalized bed material size distributions were constructed. The generalized size distributions are shown in Fig. 5. Curve A has a median diameter of 15 mm and characterizes riffle bed material lower in the basin, while curve B has a median diameter of 20 mm, and characterizes riffle bed material higher in the basin.

Relations between bed material transport rate and discharge were computed for each of the Poplar River gaging stations using the generalized bed material distributions and flow characteristics from discharge measurements. Three different bed material transport equations, Meyer - Peter & Mueller, Schoklitsch, (see Vanoni 1975), and Engelund and Hansen (1967), were used. These equations indicated that bed material transport is negligible at all gaging stations in the Poplar River basin. Thus, the stream channels of the Poplar River basin are already armored, and no degradation of the stream bed due to the operation of Cookson Reservoir is likely.

The extent of stream bank erosion is quite difficult to anticipate, because the processes are not fully understood. Nevertheless, qualitative estimates are possible. Channel banks in the Poplar River basin, especially those in the upper half of the basin appear to be quite cohesive and resistent to erosion. This resistance is due to a high percentage of silt and clay in bank material, and a thick grass sod, the roots of which hold the bank material together. Given these conditions and the reduced discharges, it does not appear that bank erosion will be significant.

Consequently, it is unlikely that sediment-free releases from Cookson Reservoir will degrade the stream bed of the East Poplar River. No tendency toward channel enlargement is to be expected, and the reduction in the magnitude of channel-forming discharges will be the dominant influence upon the channel downstream from Cookson Reservoir. Accordingly, the percentage changes in the velocity, depth and width of flow shown in Tables 2 and 3 probably represent the best estimates of the effect of Cookson Reservoir upon the East Poplar River at the International Boundary.

Rate of Stream Channel Adjustment

Adjustment of the hydraulic characteristics of the East Poplar River to the reduced discharges will probably occur over a period of decades. There is at present no way to compute the exact amount of time required for a stream to adjust completely to new conditions of water and sediment discharge.

Table 5. Size distributions of stream bed material in the Poplar River basin.

Site Location	Pool (P) Riffle (R)	D_5 (mm)	D_{16} (mm)	D_{35} (mm)	D_{50} (mm)	D_{65} (mm)	D_{84} (mm)	D_{95} (mm)
East Poplar River 2.5. miles below International Border	P	0.058	0.095	0.11	0.15	0.18	0.25	0.4
	R	0.6	4.0	12.5	21	31	39	45
East Poplar River Cromwell Slab	P	0.34	1.6	7.6	12.5	21	46	57
	R	2.7	10.25	20	36.5	52	73	84
East Poplar River at U.S.G.S. gage north of Scobey	P	0.27	1.0	4.8	9.1	16.5	31	49
	R	0.5	1.8	8.5	14	22	39	49
Poplar River at the International Border	P	2.7	8	19	33	45	63	80
	R	2.7	11	21	33.5	39	49	58
Poplar River at Hayfeldt Slab	P	0.21	0.37	6.6	21	39	56	62
	R	0.92	8.3	18	26	45	54	58
Poplar River at Ofstedal Slab	P	0.18	0.255	0.30	0.345	0.44	0.79	1.20
	R	4.7	10.5	19.5	28	37	68	75

Table 5. (Cont'd.)

Site Location	Pool (P) Riffle (R)	D_5 (mm)	D_{16} (mm)	D_{35} (mm)	D_{50} (mm)	D_{65} (mm)	D_{84} (mm)	D_{95} (mm)
West Poplar River south of Peerless	P	0.35	4.3	10.0	15.5	20.5	39.5	54
	R	4.2	10.5	25.5	48	68	79	86
West Poplar River as Susag Farm	P	1.4	10.0	30	40	51	66	68
	R	0.32	1.8	7.6	14	32	56	68
Poplar River at Paulsen Slab	P	0.062	0.099	0.135	0.165	0.21	0.33	0.45
	R	0.31	1.4	8.0	15	22	41	48

Some streams adjust within a few years, while others require centuries, depending upon the relative magnitude of the sediment load, and the vigor of aquatic and riparian vegetation. Frickel (1972) described the adjustment of Willow Creek near Glasgow, Montana to flood control structures that reduced flood peaks by approximately 45 percent. Twelve years after construction, bankfull channel capacity had decreased by 30 percent, which is approximately half of the complete adjustment expected. Gregory and Park (1974) described a somewhat more rapid rate of adjustment by a stream in Great Britain. Flood discharges had been reduced by 40 percent, and as a result channel capacity decreased by 54 percent in 14 years. These examples serve only as guides to assessing the rate of channel adjustment of the East Poplar River. It appears probable, though, that complete adjustment of the East Poplar River will occur over 30 to 50 years, or about the anticipated duration of the power plant operation.

Downstream Extent of Stream Channel Adjustment

The influence of a reservoir decreases downstream as the portion of the contributing drainage area controlled by the reservoir decreases. The changes in channel characteristics listed in tables 2, and 3 are for the East Poplar River at the International Boundary, which is about 5 km downstream of Cookson Reservoir. Downstream from the International Boundary, the magnitude of channel changes will decrease. It is not possible to estimate the specific magnitude and extent of channel changes further downstream because the probable discharges are not known. Gregory and Park (1974) found that the influence of a reservoir upon the channel cross-section extended downstream until the drainage area contributing to the river was at least 4 times that controlled by the reservoir. Assuming a general similarity of conditions, the effect of Cookson Reservoir will reach downstream to near the confluence of the main-stem and West Poplar River. If the flow of the Poplar River were also controlled near the International Boundary, the entire main-stem Poplar River probably would be affected downstream to its confluence with the Missouri River.

POOL AND RIFFLE SEQUENCE

The sediment load of a river is commonly divided into two fractions: the suspended load and the bedload. The suspended load is composed of the smaller particles, clay, silt, and fine sand, and is transported within the streamflow by turbulence. The bedload is composed of the relatively coarser particles which roll, bounce, or slide along the streambed. In most rivers, suspended particles comprise 80 percent or more of the total sediment load, although it may be only 10 to 20 percent of the bed material. This is because the finer particles are more easily entrained into the streamflow and move more rapidly than the relatively coarse bedload material. Thus, coarser bed material constitutes a small fraction of the

sediment load. Nevertheless, the movement of coarsest material particles has an important influence on stream morphology and the aquatic habitat.

A common channel feature of streams which transport some coarse material is the pool and riffle sequence. Langbein and Leopold (1968) have shown that coarse particles in transport will be spatially concentrated into kinematic waves. The crests of these waves are riffles and the troughs are pools. Because these gravel waves will form whenever a limited supply of gravel is being transported, the pool and riffle sequence may be regarded as a primary channel feature.

The pool and riffle sequence provides an important diversity of habitats in the aquatic environment. Riffles are frequently the preferred spawning areas for many species of fish, as well as being a significant habitat for invertebrates. Pools provide a place to hide, rest and forage. Without this sequence of shallows and deeps, the stream environment would be dramatically altered.

As noted previously, movement of the coarse fraction of the bed material is essential to the formation and maintenance of the pool and riffle sequence. Movement of bed material depends upon the shear stress applied to the stream bed. Shear stress, τ, is the product of the unit weight of water, γ, times the depth, d, times the slope, S. Because stream depth increases with discharge, the size of material in transport also increases. Shields (1936) developed a widely used relation between sediment size and the critical or threshold shear stress at which movement begins. The Shields' criterion can be used to compute the size of sediment moved by a given discharge when the flow condition and size of bed material are known.

Computed relations between discharge and the sediment size on the threshold of movement are shown in Figure 6 for 8 gaging stations in the Poplar River basin. The generalized bed material size distributions, described previously, were used. These relations are only approximate for the finer size fractions of the stream bed. The Shields' criterion was developed for flow over a bed of uniform size material. In a stream, however, there is a tendency for the finer particles to "hide" behind the coarser particles. Thus, a greater discharge (shear stress) is required in initiate motion of a given particle size when it is mixed with larger grains. The specific relationships between various particle sizes, and their effect on the rate of sediment movement, are unknown. Due to this uncertainty the relations are dashed between the 16th and 35th percentile fraction and are not extended to grain sizes smaller than the 16th percentile.

The several graphs indicate rather similar degrees of bed material movement at the 8 cross sections surveyed within the Poplar River basin. At all sites, discharges greater than the mean annual flood, $Q_{2.3}$, are necessary to move bed particles larger than the 35th percentile particle size. Particles equal or greater than the median diameter are moved

by discharges less than 50-year flood at only two gaging stations.

These graphs indicate that the movement of bed material in the Poplar River system, except for the finer size fractions, is exceedingly small. Under natural conditions, however, a well developed pool and riffle sequence has formed in the stream channels of the Poplar River basin. Thus, the movement of coarse bed material has been sufficient to form and maintain a pool and riffle sequence. Relatively rare floods with recurrence intervals of 10-100 years on the annual flood series appear to be required to form the pool and riffle sequence. Any appreciable reduction in the magnitude of flood discharges will probably result in insufficient coarse bed material movement to form the pool and riffle sequence. The pool and riffle sequence which presently exists in the East Poplar River would become a remnant. How long the relic pool and riffle sequence would exist without maintenence is unknown.

SUMMARY OF CONCLUSIONS

1. Operation of Cookson Reservoir and consumption of water by a one unit power plant will reduce the 1.5 year flood discharge of the East Poplar River at the International Boundary from 17.5 m^3/sec to between 7 m^3/sec and 3 m^3/sec. A second power plant unit will further reduce the range of 1.5 year flood discharge to between 4 m^3/sec and 2 m^3/sec.

2. Stream channels in the Poplar River basin are well armored and have cohesive banks. Therefore, sediment-free water releases from reservoirs will probably not erode the channels immediately downstream.

3. Owing to the reduction in the magnitude of channel-forming discharges due to Cookson reservoir and a one unit power plant, the bankfull hydraulic characteristics of the East Poplar River at the International Boundary will be reduced by 38 to 60 percent in width, 30 to 49 percent in depth and 10 to 17 percent in velocity. The addition of a second power plant unit will result in a net decrease of 53 to 68 percent in width, 42 to 56 percent in depth, and 15 to 21 percent in velocity at the bankfull discharge.

   The proposed Poplar River reservoir will not reduce the magnitude of channel-forming discharges as much as that described for the East Poplar River. Bankfull discharge will probably become 4 to 10 percent slower, 13 to 31 percent shallower, and 17 to 40 percent narrower, due to regulation and diversion of flow.

4. Downstream from the International Boundary, the influence of Cookson reservoir will decrease gradually, and some changes will probably be observable as far as the confluence of the main-stem with the West Poplar River.

5. Complete adjustment of the East Poplar River to the altered flow regime will probably occur over 30 to 50 years.

6. The threshold of incipient motion of the coarser bed material particles is rarely exceeded even by the naturally occurring discharges. Reduction of flood discharges by Cookson reservoir will probably diminish the level of coarse bed material movement below that necessary to form and maintain a pool and riffle sequence.

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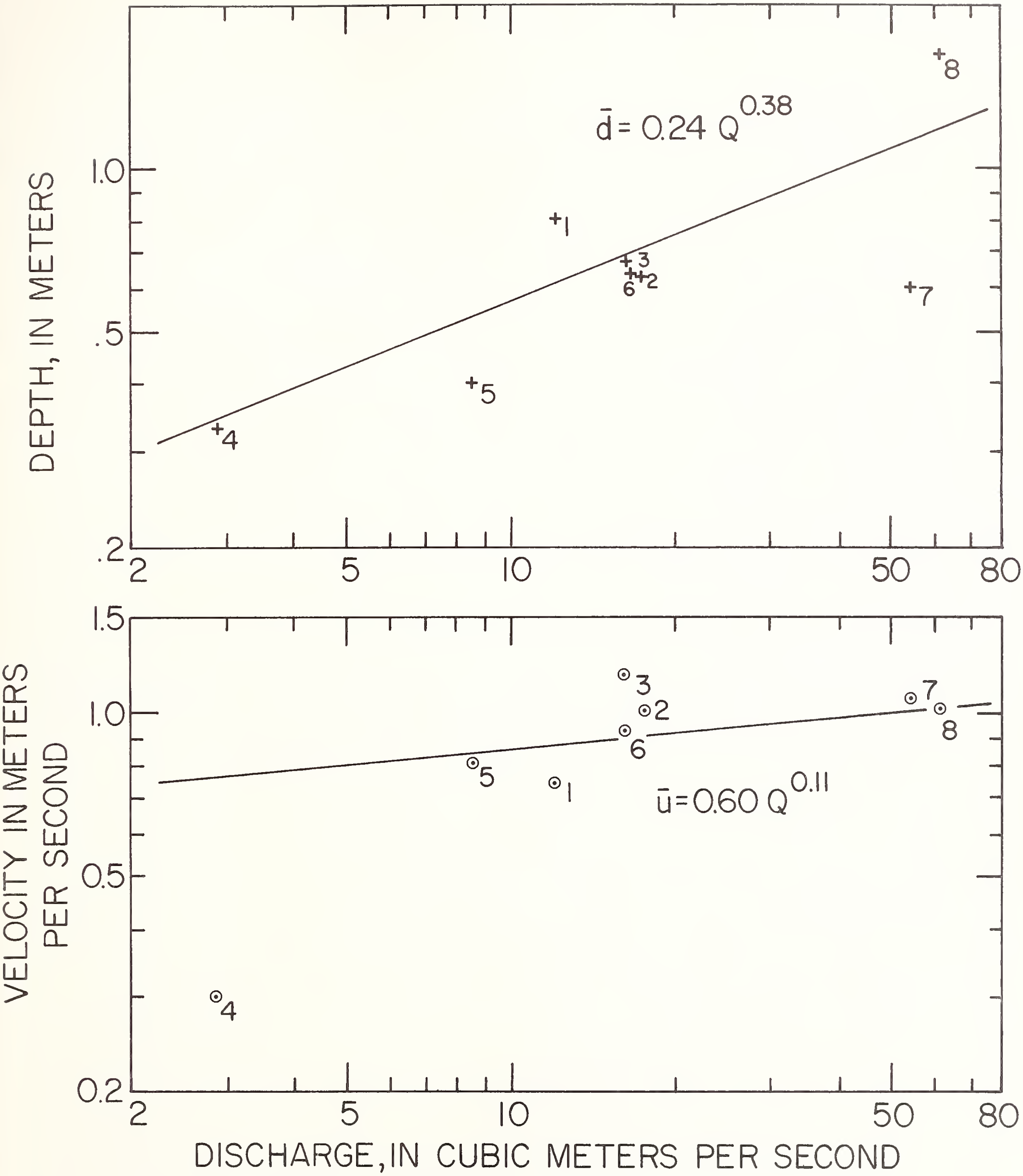


Fig. 1. Downstream hydraulic geometry of the Poplar River Basin.

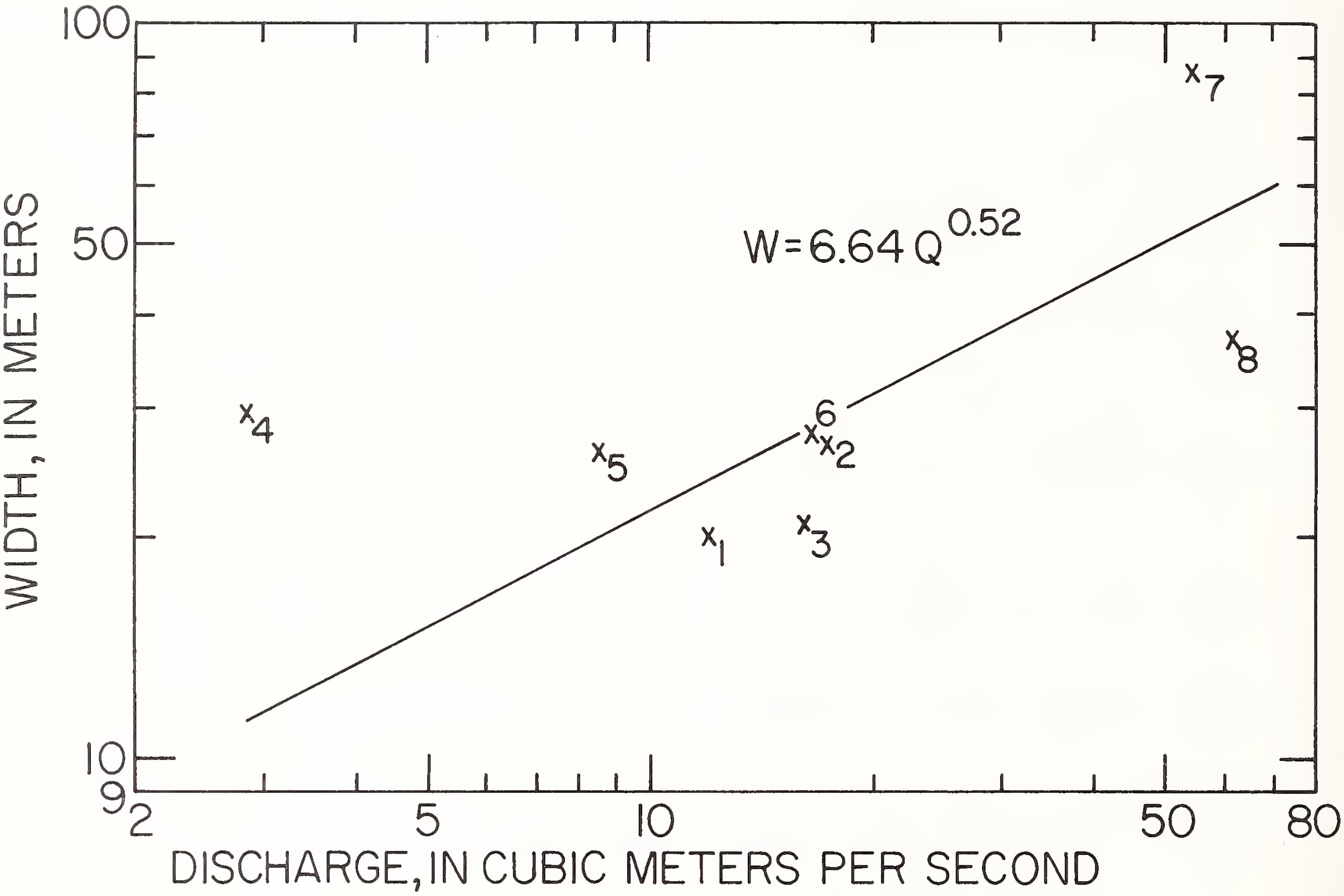

100
50
10
9
2
5
10
50
80
WIDTH, IN METERS
DISCHARGE, IN CUBIC METERS PER SECOND
$W = 6.64\,Q^{0.52}$
x1
x2
x3
x4
x5
x6
x7
x8

Fig. 1. (cont'd)

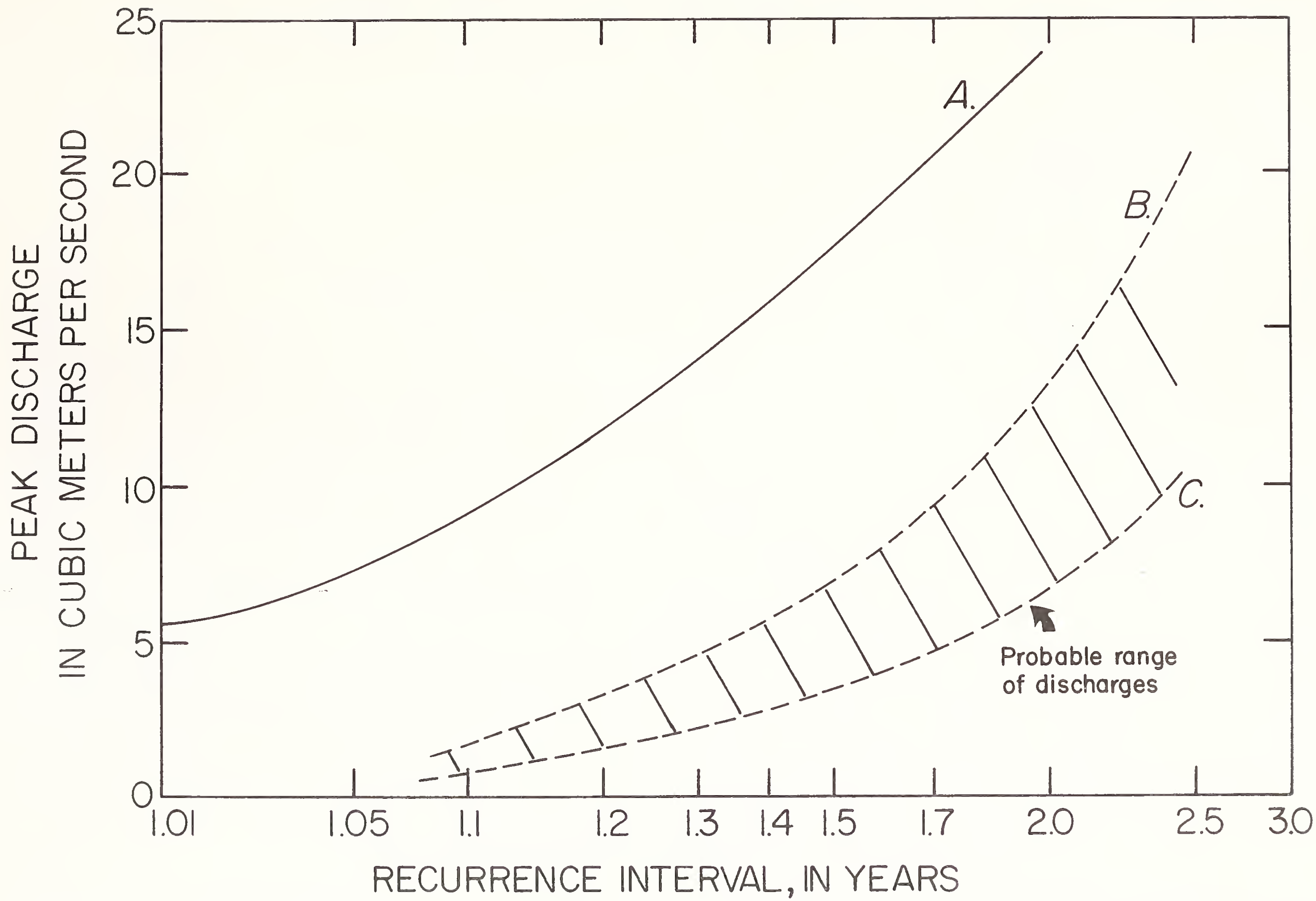


Fig. 2. Recurrence interval at peak discharges in the East Poplar River at the International Boundary; A. historical record, B. probable upper limit, and C. lower limit with reservoir and a one unit power plant.

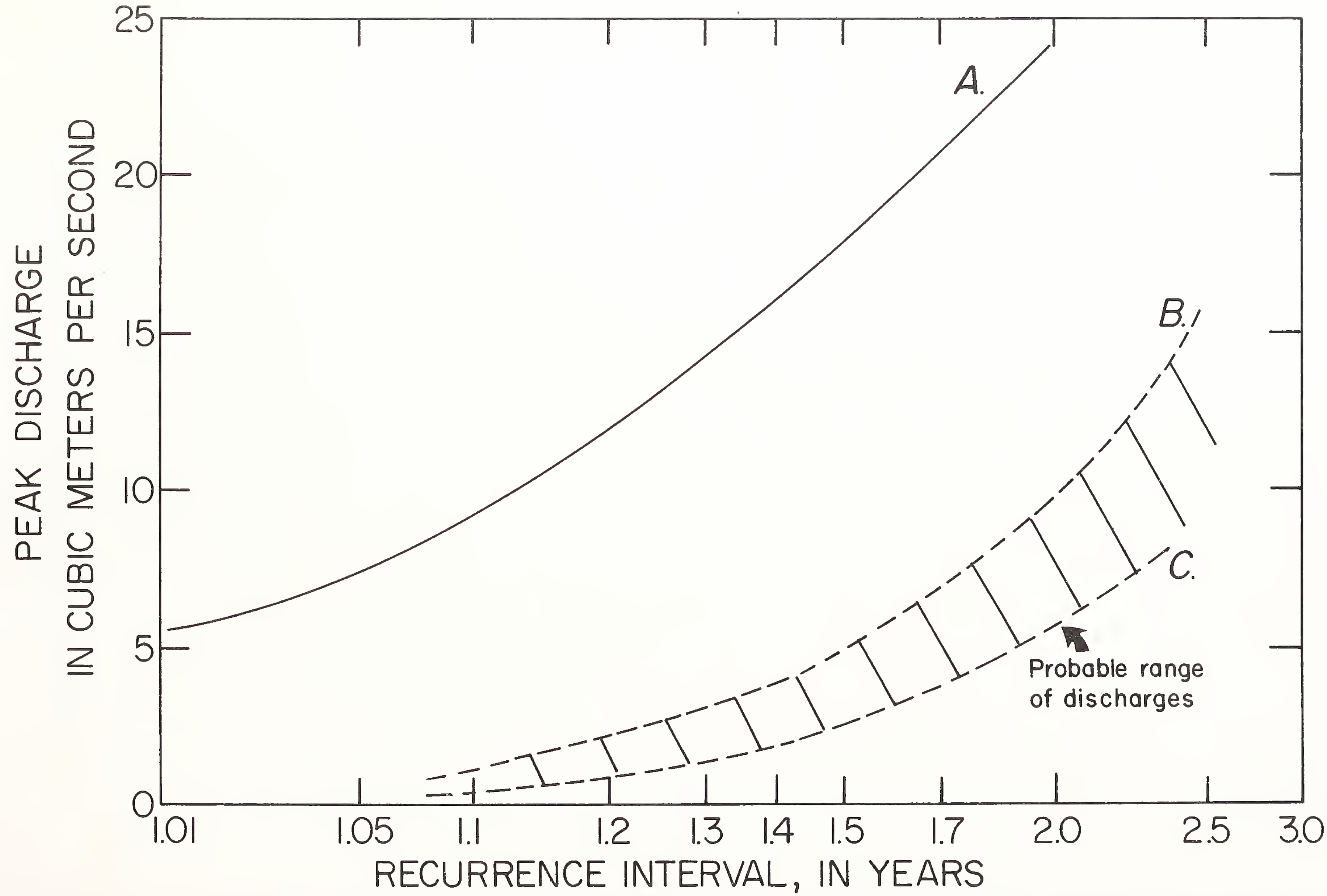


Fig. 3. Recurrence interval of peak discharges in the East Poplar River at the International Boundary; A. historical discharges, B. probable upper limit, and C. lower limit with reservoir and a two unit power plant.

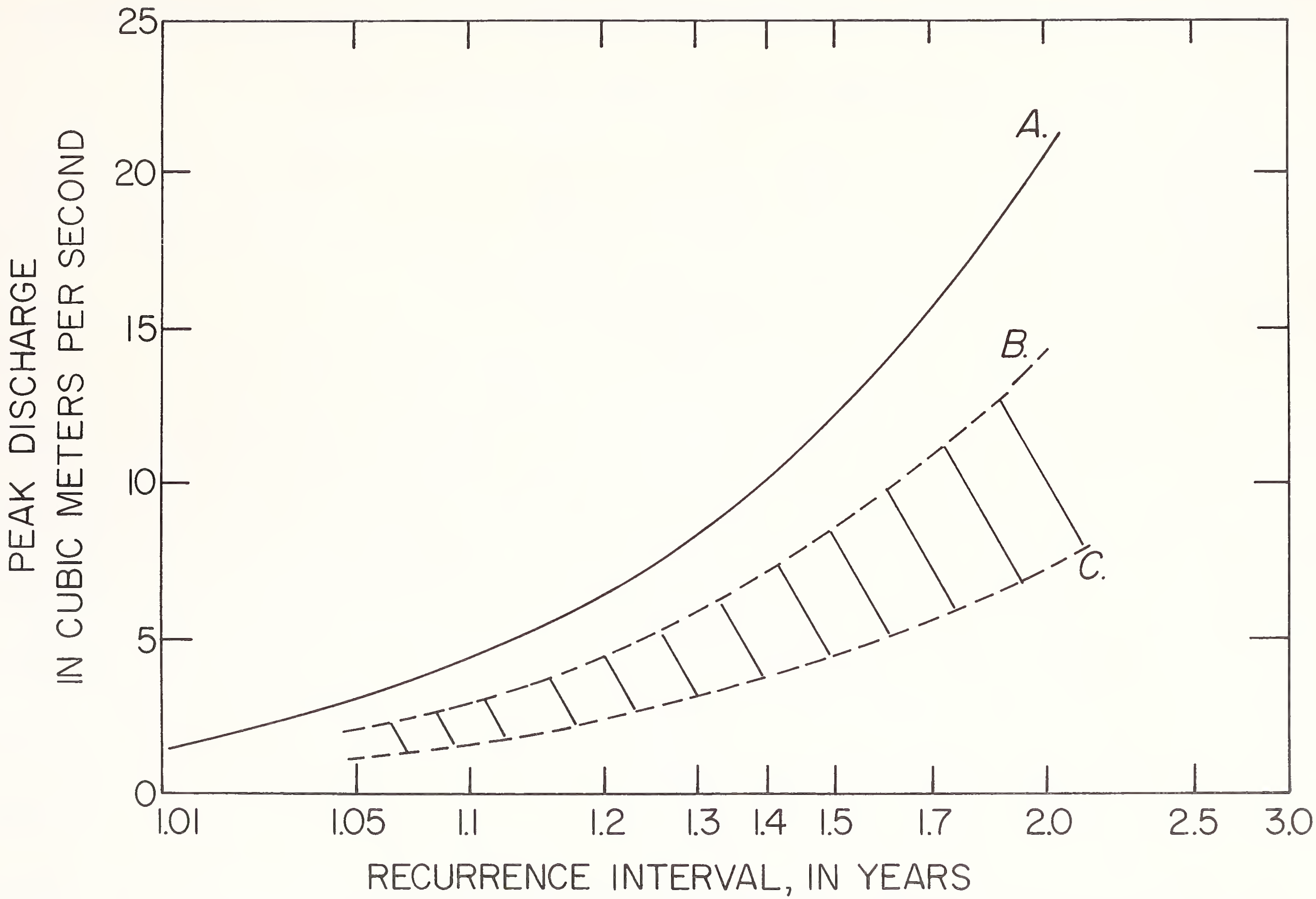


Fig. 4. Recurrence interval of peak discharges in the Poplar River at the International Boundary; A. historical discharges, B. probable upper limits, and C. probable lower limit with reservoir.

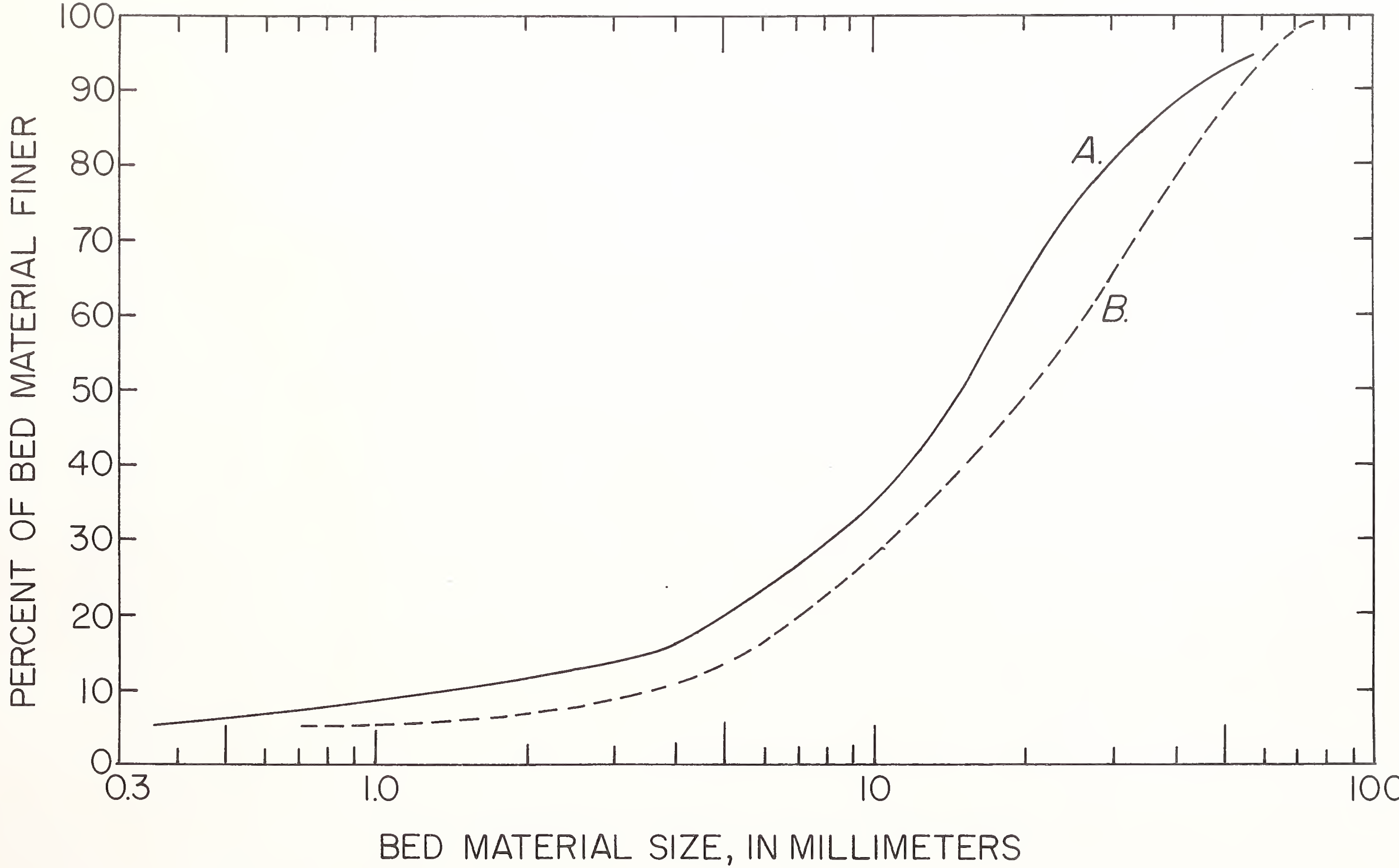


Fig. 5. Generalized bed material size distributions for the Poplar River Basin; A. lower basin, and B. upper basin.

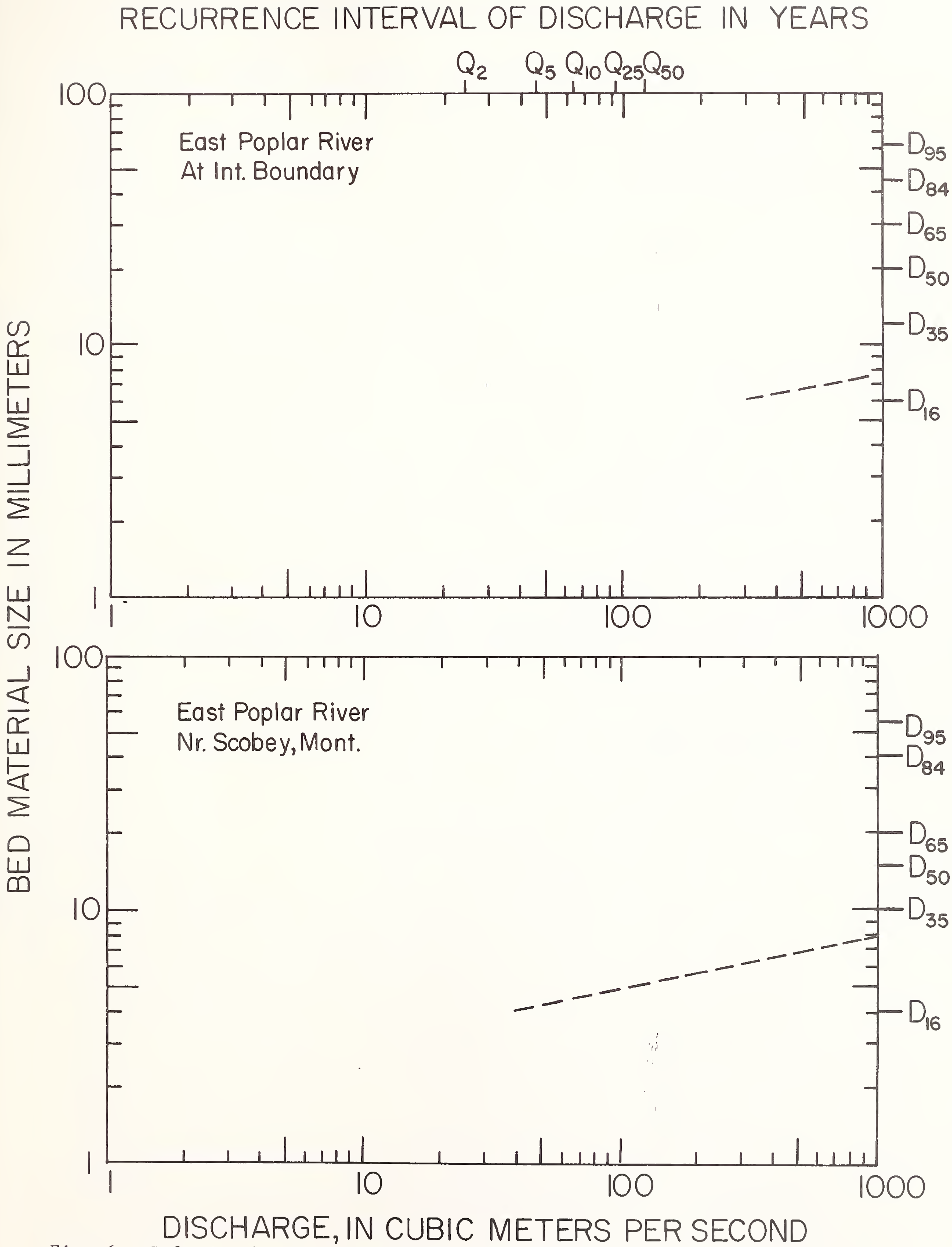


Fig. 6. Relation between discharge and incipient motion the bed material by size for the Poplar River Basin.

(cont'd)

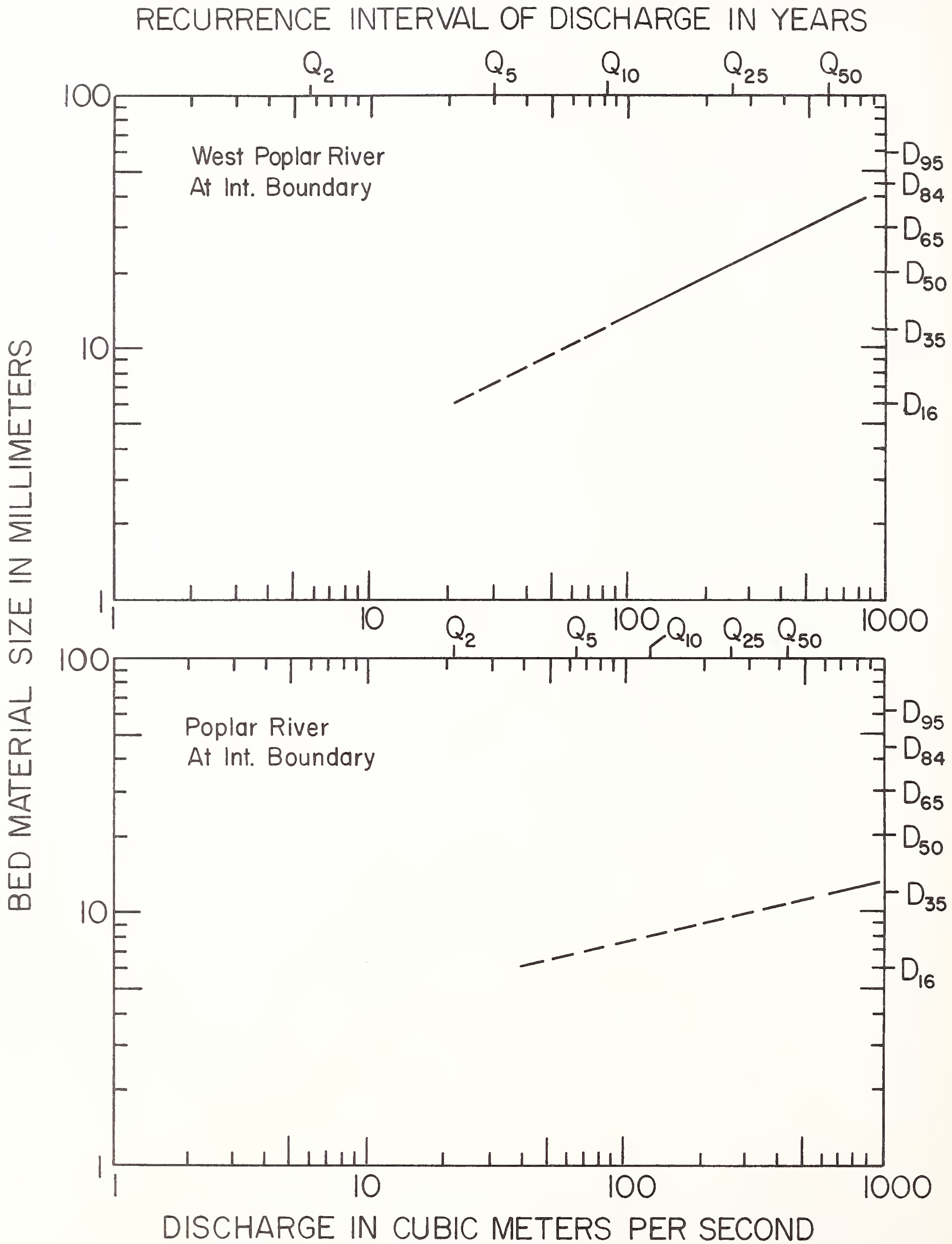


Fig. 6. (cont'd)

(cont'd)

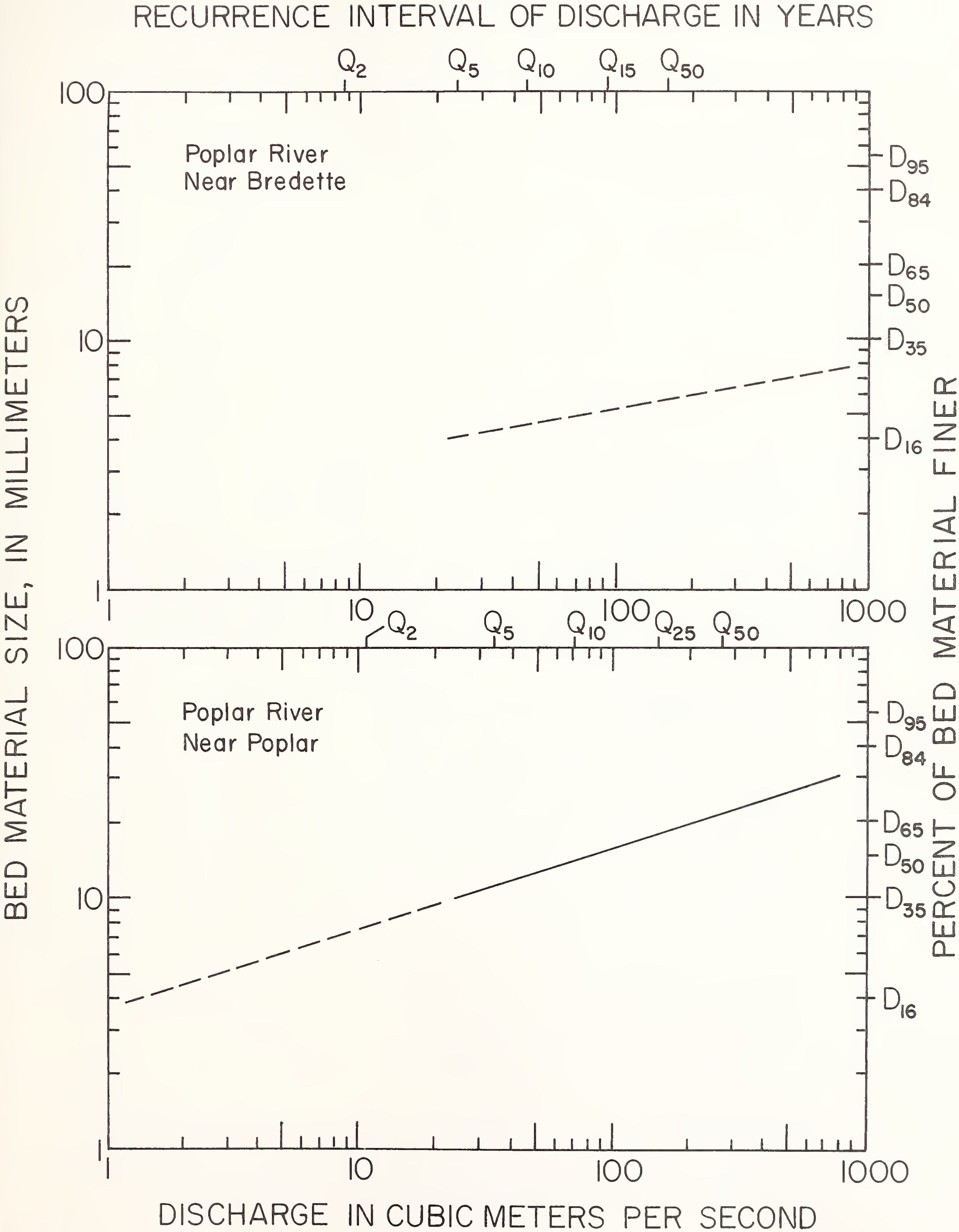


Fig. 6. (cont'd)

(cont'd)

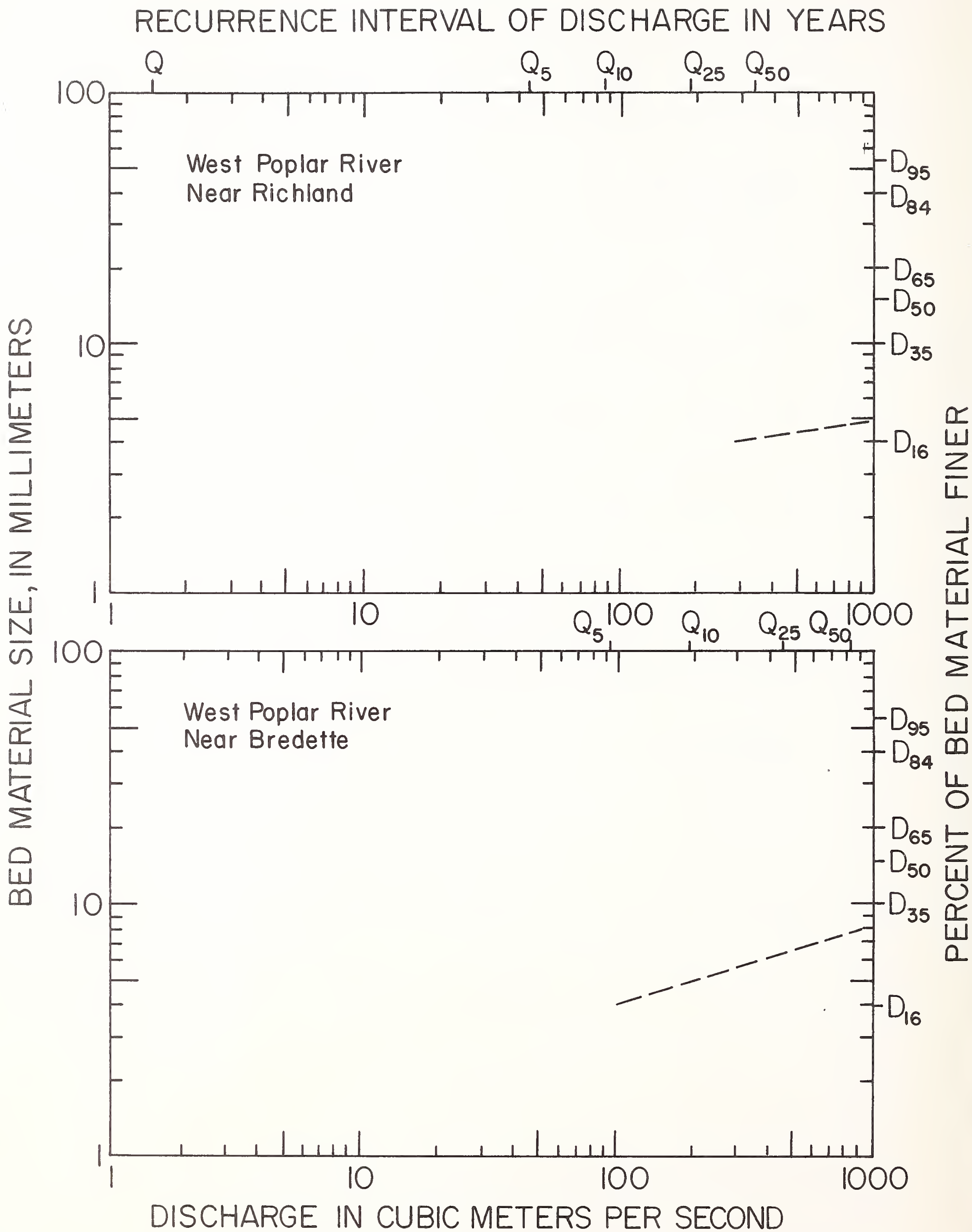
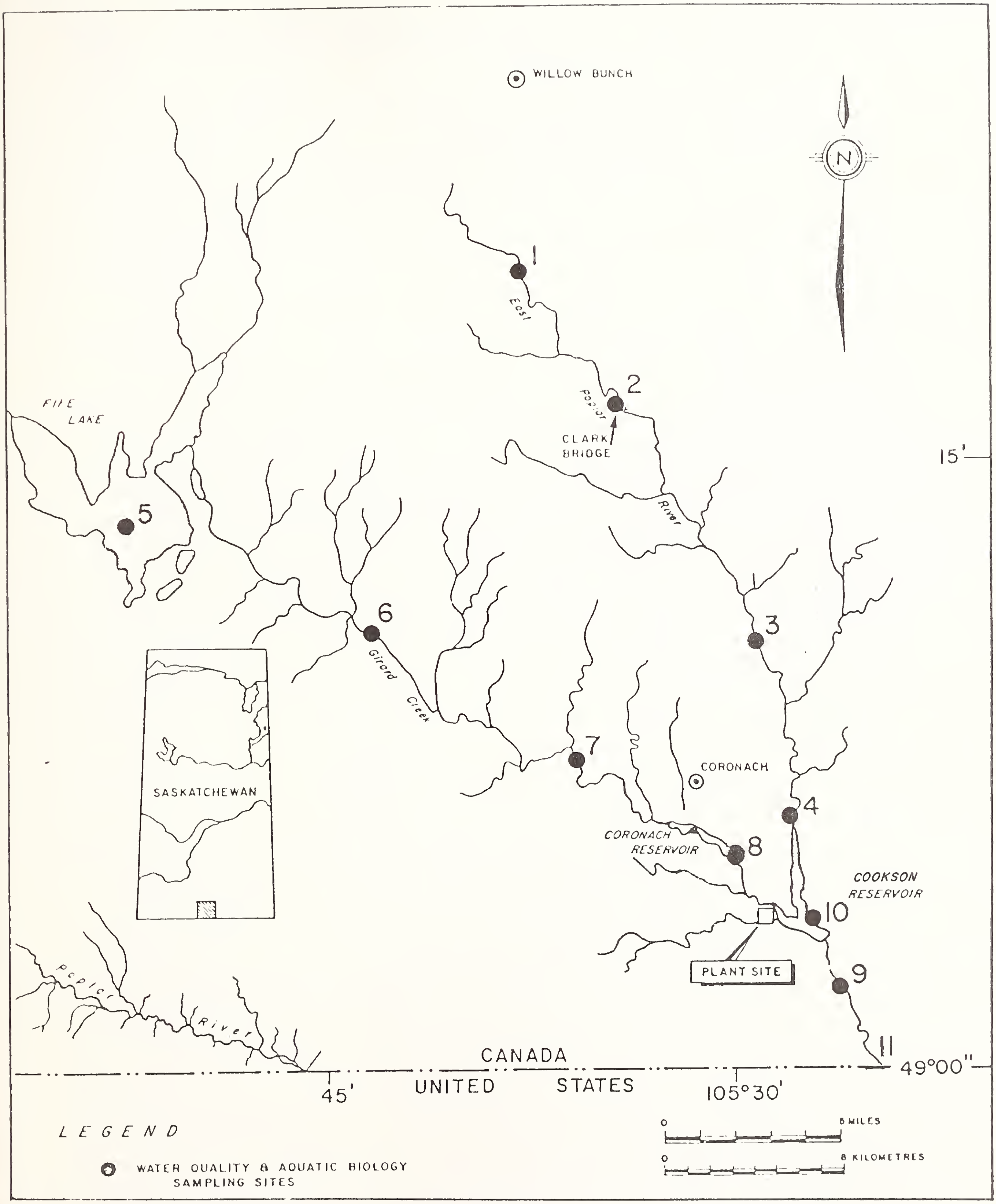

RECURRENCE INTERVAL OF DISCHARGE IN YEARS
Q
Q5
Q10
Q25
Q50
100
10
1
West Poplar River
Near Richland
D95
D84
D65
D50
D35
D16
1
10
Q5
100
Q10
Q25
Q50
1000
100
10
1
West Poplar River
Near Bredette
D95
D84
D65
D50
D35
D16
1
10
100
1000
DISCHARGE IN CUBIC METERS PER SECOND
BED MATERIAL SIZE, IN MILLIMETERS
PERCENT OF BED MATERIAL FINER

Fig. 6. (cont'd)

Annex 5. Invertebrate sampling sites - Poplar River Basin, Saskatchewan.



Annex 6. Average numbers of zooplankton (No./*l*) collected from the Poplar River, 1974.[1]

	Girard Creek				East Poplar R.	
Site Number	5	6	7	8	4	9
Daphnia sp.	3	23.5	10.3	1.3	0.7	0.3
Cyclops sp.	0.3	6.7	6.3[2]	4.2	0.7	0.3
Ostracoda	1	45.0	36.7[2]	2.0	0.7	0.3

[1]SOURCE: Cullimore, D. R. 1976. A biological survey of two river basins: East Poplar and Wood River in Saskatchewan 1974-1976. Final Report, Regina Water Research Institute Report No. 16, University of Regina, Saskatchewan. 134 p.

[2]All due to excessive numbers in July, not present in any other month.

Annex 7. Zooplankton (organisms/l) in the Poplar River Basin, 1977.[1]

	E. Poplar Site 1		E. Poplar Site 3	
	22/4/77	3/6/77	21/4/77	2/6/77
Protozoa				
Vorticella sp.			31	
Coelenterata				
Hydra sp.	5.3			
Gastrotricha				
Unidentified				1.7
Rotifera				
Brachionus angularis				19.6
Brachionus quadridentata		0.3		
Brachionus sp.	1.7		63	45.8
Cyrtonia tuba			104	
Epiphanes senta			240	
Euchlanis sp.			21	
Filinia longiseta			53	3.3
Keratella cochlearis	1.7	1.7	31	131
Keratella quadrata	9.8	1.7		98
Notholca sp.		0.2		
Polyarthra sp.		0.2	1333	13.1
Trichocerca sp.				0.3
Unidentified		0.2		
Eggs	8.2	4.9	896	140
Nematoda				
Unidentified		0.2	1	
Cladocera				
Bosmina longispina		24.5		
Daphnia pulex		29.4		
Moina sp.		3.3		
Copepoda				
Unidentified Nauplius larvae	194	26.2	2.1	26.2
Unidentified eggs	36			
Cyclopoida				
Cyclops varicans		8.2	309	1.7
Calanoida				
Diaptomus sp.		1.7		
Ostracoda				
Unidentified		0.3		6.5
Total Organisms/l (excluding eggs)	212.5	98.1	2188.1	347.2
Total No. of Taxonomic Groups	7	15	12	12

Annex 7. (Cont'd.)

	Poplar R. Site 4		Poplar R. Site 9	
	21/4/77	3/6/77	21/4/77	3/6/77
Protozoa				
Oxytricha sp.		14		
Phacodinium sp.		1.3		
Vorticella sp.	13.1		0.7	
Rotifera				
Brachionus angularis	3.3	0.7		
Brachionus calcyiflorus	13.1			
Brachionus plicatilis	3.3		0.3	
Brachionus sp.		0.7		0.7
Filinia longiseta			0.7	0.7
Keratella cochlearis	124	71	0.7	2.6
Keratella quadrata	3.3		4.8	1.3
Notholca sp.				
Polyarthra sp.	92			
Trichocerca sp.		2.7		
Eggs	170	47		13.1
Nematoda				
Unidentified			0.2	0.7
Cladocera				
Bosmina longirostris				13.1
Daphnia longispina				6.5
Daphnia pulex		1.3		2.6
Polyphemus pediculus		12		6.5
Unidentified (damaged)	0.2			
Copepoda				
Unidentified Nauplius larvae	0.7	39	3.2	33
Cyclopoida				
Cyclops varicans				6.5
Calanoida				
Diaptomus sp.		3.3	0.7	104
Unidentified (damaged)	0.2			
Eggs				1.7
Total No. of Organisms/*l* (excluding eggs)	253.2	146	11.3	178.2
Total No. of Taxonomic Groups	11	11	8	14

Annex 7. (Cont'd.)

	Girard Creek Site 6		Girard Creek Site 7	
	22/4/77	1/6/77	22/4/77	2/6/77
Protozoa				
Oxytricha sp.	83			
Phacodinium sp.	1,375			
Vorticella sp.	42			
Rotifera				
Brachionus angularis		2,833	13.1	
Brachionus calyciflorus		5,417		
Brachionus plicatilis	4.2	417	9.8	10.4
Brachionus sp.	21	167	39	20.8
Filinia longiseta	4.2	250	0.3	239.6
Keratella cochlearis	21	1,917	3.3	10.4
Keratella quadrata	542	3,000	9.8	62.5
Notholca sp.	0.3			
Polyarthra sp.	10.5	917	6.5	62.5
Unidentified		83		10.4
Eggs	104	9,250	65	281
Nematoda				
Unidentified	1.7			
Cladocera				
Daphnia sp.			0.2	
Moina macrocopa				0.7
Moina sp.				0.7
Copepoda				
Unidentified Nauplius larvae	4	26	0.3	167
Cyclopoida				
Cyclops varicans			0.3	42.5
Cyclops sp.			0.7	
Calanoida				
Diaptomus sp.	0.3		0.2	
Hydracarina				
Eylais sp.		0.1		
Ostracoda				
Unidentified				16.3
Total No. of Organisms/l (excluding eggs)	2,109.2	15,027.1	83.5	643.8
Total No. of Taxonomic Groups	14	12	13	13

[1]SOURCE: Saskmont Engineering Company. 1978. Poplar River reservoir final environmental assessment for Saskatchewan Power Corporation. Vol. I and II. 691 p.

Annex 8. Benthic fauna (organisms/m^2) in the East Poplar River Basin, September 1975.[1]

Organism	Girard Creek		East Poplar River		
	Site 6	Site 7	Site 3	Site 4	Site 9
Nematoda			44×10^7		
Mollusca					
Lymnaeidae					
Lymnaea sp.	1,440	760	690		450
Planorbidae					
Planorbis sp.			1,070		1,210
Sphaeriidae					
Pisidium sp.			460	460	
Annelidae					
Tubificidae *Tubifex* sp.					1,300
Diptera					
Ceratopogonidae					
Dasyhelea sp.	150				
Chironomidae					
Tendipes sp.	1,060				
Tipulidae					
Tipula sp.		80			
Amphipoda					
Gammarus sp.		150			
Total No. Organisms/m^2	2,650	990	44×10^7	460	2,960

[1]SOURCE: Cullimore, D. R. 1976. A biological survey of two river basins: East Poplar and Wood River in Saskatchewan 1974-1976. Final Report, Regina Water Research Institute Report No. 16, University of Regina, Saskatchewan. 134 p.

Annex 9. Benthic fauna (organisms/m^2) in the East Poplar River system in Canada, April 1977.[1]

East Poplar River Site 1 - April 22/77			
Species	Mean Wet Weight (g/m^2)		Mean Number/m^2
Chironomidae			
Chironomus riparius			14.4
Endochironomus nigricans			43.1
Glyptotendipes senilis			57.4
Polypedilum halterale			57.4
Total	No.		172.3
	Wt.	0.0761	
Tabanidae			
Chrysops sp.	No.		28.7
	Wt.	0.1264	
Coleoptera			
Haliplus (triopsis?)	No.		14.4
	Wt.	0.0014	
Oligochaeta	No.		2640.9
	Wt.	3.4264	
Sphaeriidae*	No.		2885.0
	Wt.	3.6707	
Gastropoda*			
Promenetus exacuous			43.1
Lymnaea (Bulimnea) megasoma			28.7
Total	No.		71.8
	Wt.	0.1652	
Grand Total for Site (10 taxa)		7.4662	5813.1

East Poplar River Site 9 - April 21/77			
Species	Mean Wet Weight (g/m^2)		Mean Number/m^2
Chironomidae			
Procladius sp.			28.7
Unidentified larvae			43.1
Diamesinae pupa			14.4
Tendipedinae pupa			28.7
Total	No.		114.9
	Wt.	0.0072	

Annex 9. (Cont'd.)

East Poplar River Site 9 - April 21/77 (Cont'd.)

Species	Mean Wet Weight (g/m^2)	Mean Number/m^2
Oligochaeta	No. Wt. 1.1062	1191.5
Hirudinea	No. Wt. 0.0014	14.4
Grand Total for Site (6 taxa)	1.1148	1320.8

East Poplar River Site 3 - April 21/77

Species	Mean Wet Weight (g/m^2)	Mean Number/m^2
Chironomidae		
Ablabesmyia (?) sp.		14.4
Chironomus riparius		100.0
Chironomus sp.		14.4
C. decorus		71.8
Cricotopus sp.		28.7
Cryptochironomus sp.		71.8
Dictrotendipes sp.		976.0
Endochironomus nigricans		144.0
Glyptotendipes senilis		316.0
Harnischia group		273.0
Micropsectra sp. (=*Tanytarsus coracina Joh.*)		144.0
Parachironomus sp.		14.4
Paratendipes albimanus		201.0
Polypedilum halterale		86.1
Procladius sp.		1679.0
Synchironomus (?) sp.		14.4
Tanytarsus sp.		345.0
Pupae		28.7
Unidentified		28.7
Total	No. Wt. 2.2742	4551.4
Oligochaeta	No. Wt. 2.2314	2756.0
Ephemeroptera		
Caenis simulans	No. Wt. 0.0345	43.1

East Poplar River Site 3 - April 21/77 (Cont'd.)			
Species		Mean Wet Weight (g/m^2)	Mean Number/m^2
Coleoptera			
Elmidae	No.		402.0
	Wt.	0.3980	
Hirudinea	No.		14.1
	Wt.	1.9251	
Grand Total for Site (23 taxa)		6.8632	7766.6

East Poplar River Site 4 - April 21/77			
Species		Mean Wet Weight (g/m^2)	Mean Number/m^2
Chironomidae			
Chironomus anthracinus or *decorus*			172.0
Chironomus riparius			71.8
Unidentified			28.7
Total	No.		272.5
	Wt.	2.0501	
Oligochaeta	No.		100.0
	Wt.	0.1092	
Grand Total for Site (4 taxa)		2.1593	372.5

Girard Creek Site 6 - April 22/77			
Species		Mean Wet Weight (g/m^2)	Mean Number/m^2
Chironomidae			
Chironomus sp. (pupa)			14.4
Einfeldia insolita (?)			344.5
Glyptotendipes polytomus			28.7
G. senilis			14.4
Cryptochironomus sp.			100.5
Cricotopus trifasciatus			43.1
Micropsectra sp.			43.1
Total	No.		588.7
	Wt.	4.4508	

Annex 9. (Cont'd.)

Girard Creek Site 6 - April 22/77 (Cont'd.)			
Species		Mean Wet Weight (g/m^2)	Mean Number/m^2
Heleidae			
Palpomyia group	No.		43.1
	Wt.	0.0201	
Oligochaeta	No.		301.4
	Wt.	0.1365	
Grand Total for Site (9 taxa)		4.6074	933.2

Girard Creek Site 7 - April 22/77			
Species		Mean Wet Weight (g/m^2)	Mean Number/m^2
Chironomidae			
Chironomus plumosus			28.7
C. decorus or *anthracinus*			602.8
C. riparius			14.4
Cryptochironomus sp.			43.1
Polypedilum halterale			57.4
Procladius sp.			416.3
Tendipes (Limnochironomus) modestus (?)			28.7
Tanytarsus sp.			14.4
Unidentified			14.4
Total	No.		1220.2
	Wt.	2.2268	
Grand Total for Site (9 taxa)		2.2268	1220.2

[1]SOURCE: Saskmont Engineering Company. 1978. Poplar River reservoir final environmental assessment for Saskatchewan Power Corporation. Vol. I and II. 691 p.

Annex 10. Benthic fauna (organisms/m^2) in the East Poplar River and Girard Creek in Canada, June 1977.[1]

	East Poplar River				Girard Creek	
	Site 1	Site 3	Site 4	Site 9	Site 6	Site 7
Ephemeroptera		43				
Coleoptera						
Elmidae		129				
Dytiscidae *Dytiscus* sp.	14					
Diptera						
Ceratopogonidae	14		101			
Chironomidae	776	2802	287	733	647	4798
Culicidae *Chaoborus* sp.						
Odonata	72					
Trichoptera	29					
Gastropoda	172		14			
Pelecypoda Sphaeriidae	1796					
Hirudinoidea		29		14		
Oligochaeta	2572	2802	503	1178		43
Total Number Organisms/m^2	5445	5805	905	1925	647	4841
Wet Weight/m^2	47.7936	10.6414	1.2255	2.5501	1.6579	19.0330

[1]SOURCE: Saskmont Engineering Company. 1978. Poplar River reservoir final environmental assessment for Saskatchewan Power Corporation. Vol. I and II. 691 p.

Annex 11. Aquatic invertebrates (avg no/m^2) collected with a Surber sampler from the Poplar River south of the U.S. Boundary, 1977[1]

	West Poplar				East Poplar				Upper Poplar					DNS Scobey	
	DNS Scobey	West of Scobey	Avg.	Freq[2]	1	2	Avg.	Freq.	1	2	DNS Scobey	Avg.	Freq	Avg.	Freq.
Ephemeroptera															
Baetis sp.	1716	618	1167	(8)	-	818	409	(3)	4234	770	2022	2342	(12)	242	(3)
Caenis sp.	516	1092	804	(7)	29	3352	1690	(7)	5	16	-	7	(2)	-	-
Pseudocloeon sp.	1205	226	715	(8)	-	86	43	(1)	151	97	1366	538	(12)	565	(4)
Stenonema sp.	27	43	35	(3)	-	-	-	-	-	5	75	27	(3)	5	(1)
Ephoron sp.	5	-	2	(1)	-	-	-	-	-	-	-	-	-	-	-
Paraleptophlebia sp.	49	349	200	(6)	-	-	-	-	-	-	-	-	-	-	-
Heptagenia sp.	1500	527	1013	(6)	-	-	-	-	-	-	21	7	(1)	-	-
Tricorythodes sp.	-	226	113	(3)	-	-	-	-	11	11	64	29	(3)	11	(2)
Isonychia sp.	-	16	8	(1)	-	-	-	-	-	-	5	2	(1)	27	(4)
Total No. of genera	7	8	9		1	3	3		4	5	6	7		5	
No/m^2	5018	3097	4057		29	4256	2142		4401	899	3553	2952		850	
Trichoptera															
Cheumatopsyche sp.	15914	20326	18120	(8)	1133	4148	2640	(7)	15247	5832	11841	10973	(12)	2297	(4)
Hydropsyche sp.	2292	220	1256	(8)	581	70	325	(5)	1673	2298	5880	3284	(12)	1388	(4)
Agraylea sp.	226	608	417	(8)	122	1054	588	(5)	64	-	-	21	(1)	-	-
Neureclipsis sp.	11	-	5	(1)	-	-	-	-	-	-	-	-	-	-	-
Polycentropus sp.	11	-	5	(1)	7	-	3	(1)	-	-	-	-	-	-	-
Psychomyia sp.	-	-	-	-	-	81	40	(2)	-	-	123	41	(2)	-	-
Total No. of genera	5	3	5		4	4	5		3	2	3	4		2	
No/m^2	18454	21154	19804		1843	5353	3596		16984	8130	17844	14319		3685	
Diptera															
Conchapelopia sp.	1307	1103	1205	(7)	108	2017	1062	(6)	1775	188	834	932	(9)	1506	(4)
Thiemanniella sp.	225	107	166	(6)	323	27	175	(3)	-	-	81	27	(2)	-	-
Rheotanytarsus sp.	6240	5702	5971	(7)	574	914	744	(5)	1533	430	2098	1354	(7)	27	(1)
Cricotopus sp.	5757	8984	7370	(7)	31455	5514	18484	(7)	1075	107	645	609	(9)	1936	(4)
Polypedilum sp.	108	-	54	(2)	-	-	-	-	188	-	54	81	(6)	-	-
Nilotanypus sp.	81	-	40	(2)	-	-	-	-	-	-	-	-	-	-	-
Psectrocladius sp.	54	-	27	(1)	251	215	233	(3)	27	54	349	143	(3)	-	-
Cryptochironomus sp.	107	-	53	(1)	-	-	-	-	-	-	27	9	(1)	-	-
Dictrotendipes sp.	108	-	54	(2)	251	-	125	(1)	-	-	27	9	(1)	27	(1)
Orthocladius sp.	54	54	54	(2)	4914	2305	3609	(7)	1721	161	752	878	(9)	2582	(4)
Ablabesmyia sp.	80	-	40	(1)	-	-	-	-	-	-	-	-	-	80	(1)
Smittia sp.	-	807	403	(2)	-	-	-	-	-	-	-	-	-	-	-
Clinotanypus sp.	-	27	13	(1)	-	-	-	-	-	-	-	-	-	-	-
Procladius sp.	-	-	-	-	36	-	18	(1)	-	-	-	-	-	-	-
Glyptotendipes sp.	-	-	-	-	36	107	71	(3)	27	-	269	99	(3)	54	(2)
Pseudochironomus sp.	-	-	-	-	-	377	188	(3)	54	-	-	18	(1)	-	-

Annex 11. (Cont'd.)

	West Poplar				East Poplar				Upper Poplar					DNS Scobey	
	DNS Scobey	West of Scobey	Avg.	Freq[2]	1	2	Avg.	Freq.	1	2	DNS Scobey	Avg.	Freq.	Avg.	Freq.
Diplocladius sp.	-	-	-	-	-	27	13	(1)	-	-	-	-	-	-	-
Bezzia sp.	-	-	-	-	-	27	13	(1)	80	-	-	27	(1)	134	(1)
Brillia sp.	-	-	-	-	-	54	27	(1)	27	-	80	36	(2)	-	-
Paralauterborniella sp.	-	-	-	-	-	-	-	-	27	-	-	9	(1)	-	-
Cardiocladius sp.	-	-	-	-	-	-	-	-	27	-	-	9	(1)	81	(2)
Plecopteracoluthus sp.	-	-	-	-	-	-	-	-	-	-	134	45	(1)	-	-
Diamesa sp.	-	-	-	-	-	-	-	-	-	-	81	27	(2)	-	-
Paratanytarsus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	269	(2)
Tanytarsus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	27	(1)
Limnophila sp.	-	11	5	(1)	-	-	-	-	-	-	-	-	-	-	-
Simuliidae	118	-	59	(1)	1557	13063	7310	(7)	35421	7543	7500	16821	(12)	194	(2)
Total of genera	12	8	15		10	12	14		13	6	14	18		12	
No/m^2	14239 38%	16795	15514		39505	24647	32072		41982	8483	12931	21133		6917	
Hirudinea	-	-	-	-	-	21	10	(2)	-	-	-	-	-	-	-
Coleoptera															
Zaitzevia sp.	-	-	-	-	-	-	-	-	21	-	27	16	(4)	-	-
Amphipoda	-	129	64	(3)	93	1614	853	(7)	-	-	11	4	(1)	-	-
Megaloptera															
Sialis	-	-	-		-	-	-		-	-	11	4	(1)	-	-
Hydracarina	156	183	169	(7)	7	-	3	(1)	-	-	-	-	-	-	-
Number of samples	4	4	8		3	4	7		4	4	4	12		4	
Total no. of genera	25	21	29		17	21	25		21	13	26	32		19	
Total No/m^2	37862	41358	39608		41477	35864	38676		63388	17512	34377	38428		11452	

[1]SOURCE: United States Environmental Protection Agency, Region 8. Systems and Analysis Division. Unpublished data.
[2]Freq. - Frequency of occurrences.

Station	Location
West Poplar downstream from Scobey	West Poplar River at Highway 13 Bridge.
West Poplar West of Scobey	West Poplar River about six miles southwest of Peerless, Montana.
East Poplar No. 1	East Poplar at the first Highway 13 Bridge North of Scobey.
East Poplar No. 2	East Fork approximately five miles south of the U.S.-Canada border.
Upper Poplar No. 1	Upper Poplar at the first county road crossing upstream from the confluence with the East Poplar.
Upper Poplar No. 2	Upper Poplar at the second county road crossing upstream from the confluence with the East Poplar.
Upper Poplar downstream from Scobey	Upper Poplar at the Highway 13 Bridge five miles downstream from Scobey.
Downstream from Scobey	Poplar River at the first crossing upstream from the Long Creek confluence.

Annex 12. Trichoptera and Ephemeroptera collected by Surber sampler (No./ft^2) and sweep net (x indicates presence), Poplar River, May 2-4, 1978.[1]

	Surber Samples							Sweep Net Samples							
Stn.	7		8		9	11		1	2	3	6	7	8	9	11
Rep.	1	2	1	2		1	2								
Ephemeroptera															
Caenis sp.	-	-	-	1	5	1	-	-	-	x	-	x	x	-	x
Callibaetis sp.	-	-	-	-	-	-	-	x	-	x	-	-	-	-	-
Trichoptera															
Hydropsyche sp.	152	5	-	-	-	200	184	-	-	-	-	x	-	-	x
Cheumatopsyche sp.	108	15	12	28	-	47	28	-	-	-	-	x	-	-	x
A. bimaculata	-	-	-	-	-	-	-	x	-	x	x	x	-	-	-
Limnephilus sp.	-	-	-	-	-	-	-	x	-	-	x	-	-	-	x
Ptilostomis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Polycentropus sp.	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Limnephilidae	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x

[1]SOURCE: Saskatchewan Research Council. 1978. An Evaluation of the Macroinvertebrate Stream Fauna in the East Poplar River North of the Canada - U.S. Border. Report to Biological Resources Committee, International Poplar River Water Quality Board, International Joint Commission. 4 p.

Annex 13. Trichoptera and Ephemeroptera collected by Surber sampler, Poplar River, May 2-4, 1978. (Qualitative Samples) [1]

Station	WP-1	MP-4	MP-9	MP-10	EP-2	EP-4
Ephemeroptera						
Pseudocloeon cingulatum	A	A			S	
Heptagenia marginalis		S			A	
Baetis cingulatus		M	M	A	A	S
Caenis sp.			M	A		A
Trichoptera						
Helicopsyche borealis					A	S
Hydropsyche sp.		A	A	A	A	M
Cheumatopsyche sp.	S	A	M	A	A	
Psychomyia sp.		M	S	M	S	S

A = Abundant; M = Moderate in Number; S = Scarce

- WP-1 West Poplar at the Highway 13 bridge crossing.
- MP-4 Main Poplar at the Highway 13 bridge crossing downstream from Scobey.
- MP-9 Main Poplar at the first county road crossing upstream from the confluence with the East Poplar.
- MP-10 Main Poplar at the second county road crossing upstream from the confluence with the East Poplar.
- EP-2 East Poplar at the first Highway 13 bridge North of Scobey.
- EP-4 East Poplar about 5 miles South of the U.S.-Canadian border.

[1]SOURCE: Saskatchewan Research Council. 1978. An Evaluation of the Macroinvertebrate Stream Fauna in the East Poplar River North of the Canada - U.S. Border. Report to Biological Resources Committee, International Poplar River Water Quality Board, International Joint Commission. 4 p.

Annex 14. List of fish species collected or observed in the Poplar River, Saskatchewan and Montana.

Common Name	Scientific Name	East[1] Poplar, Sask.	East Poplar, Montana	Upper[2] Poplar, Montana	West Poplar, Montana	Lower[3] Poplar, Montana
Walleye	*Stizostedion vitreum*	X	X	X	X	X
Northern pike	*Esox lucius*	X	X	X	X	X
Carp	*Cyprinus carpio*	X	X	X	X	X
Goldeye	*Hiodon alosoides*	X	X	X	X	X
White sucker	*Catostomus commersoni*	X	X	X	X	X
Shorthead redhorse	*Moxostoma macrolepidotum*	X	X	X	X	X
Northern redbelly dace	*Phoxinus eos*	X	X		X	
Finescale dace	*Phoxinus neogaeus*	X				
Longnose dace	*Rhinichthys cataractae*	X	X	X	X	X
Pearl dace	*Semotilus margarita*	X				X
Brook stickleback	*Culaea inconstans*	X	X	X	X	X
Iowa darter	*Etheostoma exile*	X	X	X	X	
Fathead minnow	*Pimephales promelas*	X	X	X	X	X
Brassy minnow	*Hybognathus hankinsoni*	X				X
Lake chub	*Couesius plumbeus*	X	X	X	X	X
Rainbow trout	*Salmo gairdneri*	X				
River carpsucker	*Carpiodes carpio*					X
Bigmouth buffalo	*Ictiobus cyprinellus*					X
Smallmouth buffalo	*Ictiobus bubalus*					X
Longnose sucker	*Catostomus catostomus*					X
Black bullhead	*Ictalurus melas*				X	X
Channel catfish	*Ictalurus punctatus*					X
Stonecat	*Notorus flavus*				X	X
Yellow perch	*Perca flavescens*					X
Freshwater drum	*Aplodinotus grunniens*					X
Creek chub	*Semotilus atromaculatus*		X	X	X	
Flathead chub	*Hybopsis gracilis*				X	X
Emerald shiner	*Notropis atherinoides*		X		X	X
Silvery/plains minnow	*Hybognathus nuchalis/placitus*		X	X	X	X

Annex 14. (Cont'd.)

Common Name	Scientific Name	East[1] Poplar, Sask.	East Poplar, Montana	Upper[2] Poplar, Montana	West Poplar, Montana	Lower[3] Poplar, Montana
Smallmouth bass	*Micropterus dolomieui*				X	X
Sauger	*Stizostedion canadense*				X	X
White crappie	*Pomoxis annularis*					X
Burbot	*Lota lota*					X
Paddlefish	*Polyodon spathula*					X
Golden shiner	*Notemigonus crysoleucas*					X
Pumpkinseed	*Lepomis gibbosus*					X
Largemouth bass	*Micropterus salmoides*					X

[1]East Poplar, Saskatchewan refers to the entire East Poplar River drainage in Saskatchewan including Fife Lake, Girard Creek, Coronach Reservoir and Cookson Reservoir.

[2]Upper Poplar, Montana includes the Poplar River from the International Boundary to its confluence with the East Poplar.

[3]Lower Poplar, Montana includes the Poplar River from its confluence with the East Poplar to its confluence with the Missouri River.

Annex 15. Status and abundance of the birds observed in the Poplar River drainage in Montana during 1977 and 1978.

Species	Scientific Name	Status, Abundance
Horned grebe	*Podiceps auritus*	M-3
Eared grebe	*Podiceps nigricollis*	M-3
Pied-billed grebe	*Podilymbus podiceps*	*SR-5
White pelican	*Pelecanus erythrorhynchos*	M-4
Double-crested cormorant	*Phalacrocorax auritus*	M-4, SV-5
Great blue heron	*Ardea herodias*	SV-3
Black-crowned night heron	*Nycticorax nycticorax*	*SR-4
American bittern	*Botaurus lentiginosus*	SR-5
Whistling swan	*Olor columbianus*	M-5
Canada goose	*Branta canadensis*	*SR-4, M-3
Snow goose	*Chen caerulescens*	M-4
Mallard	*Anas platyrhynchos*	*SR-2
Gadwall	*Anas strepera*	*SR-2
Pintail	*Anas acuta*	*SR-2
Green-winged teal	*Anas crecca*	M-3
Blue-winged teal	*Anas discors*	*SR-3
American wigeon	*Anas americana*	*SR-2
Northern shoveler	*Anas clypeata*	*SR-3
Redhead	*Aythya americana*	M-4
Canvasback	*Aythya valisineria*	M-4
Lesser scaup	*Aythya affinis*	SR-5, M-3
Ring-necked duck	*Aythya collaris*	M-4
Common goldeneye	*Bucephala clangula*	M-4
Bufflehead	*Bucephala albeola*	M-4
Ruddy duck	*Oxyura jamaicensis*	M-4
Common merganser	*Mergus merganser*	SR-4, M-4
Red-tailed hawk	*Buteo jamaicensis*	M-4
Swainson's hawk	*Buteo swanisoni*	SR-3
Ferruginous hawk	*Buteo regalis*	M-4
Rough-legged hawk	*Buteo lagopus*	M-4
Golden eagle	*Aquila chrysaetos*	PR-4
Bald eagle	*Haliaeetus leucocephalus*	M-5
Marsh hawk	*Circus cyaneus*	*SR-3
Prairie falcon	*Falco mexicanus*	PR-4
American kestrel	*Falco sparverius*	SR-4, M-4
Sharp-tailed grouse	*Pediocetes phasianellus*	*PR-3
Sage grouse	*Centrocercus urophasianus*	SV-5
Ring-necked pheasant	*Phasianus colchicus*	*PR-3
Gray partridge	*Perdix perdix*	*PR-3
Sandhill crane	*Grus canadensis*	M-4
Virginia rail	*Rallus limicola*	M-5
Sora	*Porzana carolina*	SR-5
American coot	*Fulica americana*	*SR-4
Killdeer	*Charadrius vociferus*	*SR-3
Black-bellied plover	*Pluvialis squatarola*	M-4

Annex 15. (Cont'd.)

Species	Scientific Name	Status, Abundance
Common snipe	*Capella gallinago*	SR-4, M-3
Long-billed curlew	*Numenius americanus*	M-4, SV-4
Upland sandpiper	*Bartramia longicauda*	SR-4
Spotted sandpiper	*Actitis macularia*	*SR-3
Solitary sandpiper	*Tringa solitaria*	M-4
Greater yellowlegs	*Tringa melanoleuca*	SV-4, M-4
Lesser yellowlegs	*Tringa flavipes*	M-4
Willet	*Catoptrophorus semipalmatus*	*SR-3
Pectoral sandpiper	*Calidris melanotos*	M-4
Baird's sandpiper	*Calidris bairdii*	M-5
Long-billed dowitcher	*Limnodromus scolopaceus*	M-4
Marbled godwit	*Limosa fedoa*	*SR-3
American avocet	*Recurvirostra americana*	SR-4, M-4
Wilson's phalarope	*Steganopus tricolor*	M-3
Northern phalarope	*Lobipes lobatus*	M-4
California gull	*Larus californicus*	SR-4, M-4
Ring-billed gull	*Larus delawarensis*	SR-4, M-4
Franklin's gull	*Larus pipixcan*	M-3
Common tern	*Sterna hirundo*	SR-4, M-4
Black tern	*Chlidonias niger*	SR-4, M-4
Rock dove	*Columba livia*	*PR-3
Mourning dove	*Zenaida macroura*	*SR-3
Great horned owl	*Bubo virginianus*	*PR-4
Snowy owl	*Nyctea scandiaca*	WV-4
Burrowing owl	*Speotyto cunicularia*	SR-4
Short-eared owl	*Asio flammeus*	SR-4
Common nighthawk	*Chordeiles minor*	SR-4
Belted kingfisher	*Megaceryle alcyon*	SR-3
Common flicker	*Colaptes auritus*	*SR-3
Red-headed woodpecker	*Melanerpes erythrocephalus*	M-5
Downy woodpecker	*Dendrocopos pubescens*	WV-5
Eastern kingbird	*Tyrannus tyrannus*	*SR-3
Western kingbird	*Tyrannus verticalis*	*SR-3
Say's phoebe	*Sayornis saya*	SR-4
Horned lark	*Eremophila alpestris*	*PR-2
Tree swallow	*Iridoprocne bicolor*	M-4
Bank swallow	*Riparia riparia*	*SR-3
Rough-winged swallow	*Stelgidopteryx ruficollis*	M-4
Barn swallow	*Hirundo rustica*	SR-3
Cliff swallow	*Petrochelidon pyrrhonota*	*SR-3
Black-billed magpie	*Pica pica*	*PR-4
Common crow	*Corvus brachyrhynchos*	SR-4
Red-breasted nuthatch	*Sitta canadensis*	M-5
Brown creeper	*Certhia familiaris*	M-5
House wren	*Troglodytes aedon*	M-4
Gray catbird	*Dumetella carolinensis*	M-4

Species	Scientific Name	Status, Abundance
Brown thrasher	*Toxostoma rufum*	M-4
American robin	*Turdus migratorius*	*SR-4
Swainson's thrush	*Catharus ustulatus*	M-4
Mountain bluebird	*Sialia currucoides*	SR-5
Ruby-crowned kinglet	*Regulus calendula*	M-5
Bohemian waxwing	*Bombycilla garrulus*	WV-4
Cedar waxwing	*Bombycilla cedrorum*	M-4
Loggerhead shrike	*Lanius ludovicianus*	*SR-4
Starling	*Sturnus vulgaris*	*SR-4
Black-and-white warbler	*Mniotilta varia*	M-5
Tennessee warbler	*Vermivora peregrina*	M-5
Yellow warbler	*Dendroica petechia*	SR-4
Magnolia warbler	*Dendroica magnolia*	M-5
Yellow-rumped warbler	*Dendroica coronata*	M-4
Blackpoll warbler	*Dendroica striata*	M-5
Ovenbird	*Seiurus aurocapillus*	M-4
Northern waterthrush	*Seiurus noveboracensis*	M-5
Common yellowthroat	*Geothylpis trichas*	SR-4
Yellow-breasted chat	*Icteria virens*	M-4
American redstart	*Setophaga ruticilla*	M-5
House sparrow	*Passer domesticus*	*PR-3
Bobolink	*Dolichonyx oryzivorus*	SR-4
Western meadowlark	*Sturnella neglecta*	*SR-3
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	SR-4
Red-winged blackbird	*Agelaius phoeniceus*	*SR-2
Northern oriole	*Icterus galbula*	*SR-5
Brewer's blackbird	*Euphaga cyanocephalus*	SR-4
Common grackle	*Quiscalus quiscula*	SR-4
Brown-headed cowbird	*Molothrus ater*	*SR-3
Rose-breasted grosbeak	*Pheucticus ludovicianus*	M-5
Common redpoll	*Acanthis flammea*	WV-4
American goldfinch	*Spinus tristis*	*SR-4
Rufous-sided towhee	*Pipilo erythrophthalmus*	SR-5
Lark bunting	*Calamospiza melanocorys*	*SR-3
Savannah sparrow	*Passerculus sandwichensis*	SR-3
Grasshopper sparrow	*Ammodramus savannarum*	SR-4
Vesper sparrow	*Pooecetes gramineus*	*SR-3
Dark-eyed junco	*Junco hyemalis*	M-4
Tree sparrow	*Spizella arborea*	M-4
Chipping sparrow	*Spizella passerina*	M-4
Clay-colored sparrow	*Spizella pallida*	*SR-3
White-crowned sparrow	*Zonotrichia leucophrys*	M-5
Song sparrow	*Melospiza melodia*	SR-5
Chestnut-collared longspur	*Calcarius ornatus*	*SR-3
Snow bunting	*Plectrophenax nivalis*	WV-3

* Denotes definite breeding

SR - Indicates breeding, no definite evidence
SV - Nonbreeding summer visitor
PR - Permanent resident
M - Migrant
WV - Winter visitor

a - Abundant
2 - Common to very common
3 - Fairly common
4 - Uncommon
5 - Rare

Annex 16. Distribution of mammals in the Poplar River drainage in Montana during 1977 and 1978.

Species	Scientific Name	1	Habitat
Masked shrew	*Sorex cinereus*	C	Shrubby native prairie
Nuttall cottontail	*Sylvilagus nutallii*	U	Wooded ravine
White-tailed hare	*Lepus townsendii*	C	Widespread, most plentiful on native habitat
Richardson ground squirrel	*Spermophilus richardsonii*	A	Native prairie, cultivated fields
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	R	Shrubby native prairie
Beaver	*Castor canadensis*	C	Water courses, ponds
Deer mouse	*Peromyscus maniculatus*	A	Widespread
Northern grasshopper mouse	*Onychomys leucogaster*	R	Native prairie, haylands
Muskrat	*Ondatra zibethicas*	C	Water courses, ponds, sloughs
Meadow vole	*Microtus pennsylvanicus*	C	Moise meadows, native prairie
House mouse	*Mus musculus*	C	Farmyards
Porcupine	*Erethizon dorsatum*	U	Wooded ravines, farmyards
Red fox	*Vulpes fulva*	U	Widespread; brush or slough cover associated with cultivated fields
Coyote	*Canis latrans*	C	Widespread; native prairie, stream courses
Raccoon	*Procyon lotor*	C	Water courses, ponds, sloughs
Long-tailed weasel	*Mustela frenata*	U	Moderately widespread; native prairie, farmyards, croplands
Mink	*Mustela vison*	C	Water courses, ponds, sloughs
Badger	*Taxidea taxus*	U	Native grasslands, cultivated fields
Striped skunk	*Mephitis mephitis*	U	Moderately widespread
River otter	*Lutra canadensis*	R	East Poplar and Poplar River
Mule deer	*Odocoileus hemionus*	R	Hilly native prairie
White-tailed deer	*Odocoileus virginianus*	C	Moderately widespread; native prairie, farmyards, sloughs, etc.
Pronghorn antelope	*Antilocapra americana*	U	Native prairie and cultivated fields

[1] Abundance:
A (abundant) - found in large numbers in appropriate habitats.
C (common) - found in moderate numbers in appropriate habitats.
U (uncommon) - present in appropriate habitats, but in small numbers.
R (rare) - few sightings.

Annex 17. Abundance and distribution of reptiles and amphibians observed in the Poplar River drainage in Montana during 1977 and 1978.

Species	Scientific Name	Abundance and Distribution
Painted turtle	*Chrysemys picta*	Common along Poplar River
Leopard frog	*Rana pipiens*	Abundant throughout area, especially in vincity of water courses
Smooth green snake	*Opheodrys vernalis*	Uncommon, near western edge of its range, moist grassy plains
Plains garter snake	*Thamnophis radix*	Common throughout drainage